PB83-110122

National Assessment of the Urban Particulate Problem. Volume IV Birmingham, Alabama

GCA Corp.
Bedford, MA

Prepared for

Environmental Protection Agency
Research Triangle Park, NC

Jun 76

U.S. Department of Commerce
National Technical Information Service
NTIS

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
EPA 450/3-76-026b		PB83 110122

4. TITLE AND SUBTITLE	5. REPORT DATE
National Assessment of the Urban Particulate Problem; Volume IV - Birmingham	June 1976
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
David A. Lynn, Frank Record, Project Director	GCA-TR-76-25-G(4)
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT NO.
GCA Technology Division Burlington Road Bedford, MA 01730	11. CONTRACT/GRANT NO. 68-02-1376
12. SPONSORING AGENCY NAME AND ADDRESS	13. TYPE OF REPORT AND PERIOD COVERED
U. S. Environmental Protection Agency Office of Air Quality Planning and Standards Research Triangle Park, North Carolina 27711	Final 14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES Volume I, National Assessment - EPA 450/3-76-024; Volume II, Particle Characterization - EPA 450/3-76-025; Volumes III-XVI, Urban Area Reports - EPA 450/3-76-026a thru 026n.

16. ABSTRACT

This document is one volume of a sixteen-volume report presenting an overall assessment of the particulate problem, which was conducted by GCA/Technology Division for EPA.

This particular document is one of fourteen single-area volumes that provide working summaries of data gathered in the fourteen urban areas studied. These city reports primarily provide documentation and background information for Volume I of the study - National Assessment of the Particulate Problem - Final Report. Volume I should be considered the primary output of the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Particulate Matter Total Suspended Particulate Emission Sources Control Methods Air Quality Measurements	Optical Microscopy Secondary Particulates Fuel Combustion Process Emissions Fugitive Emissions Fugitive Dust Monitor Siting Meteorology	

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS (This Report)	21. NO. OF PAGES
Release Unlimited. Available for a fee, Thru the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22151	Unclassified	111
	20. SECURITY CLASS (This page)	22. PRICE
	Unclassified	

EPA Form 2220-1 (9-73)

PB83-110122

EPA-450/3-76-026b
June 1976

NATIONAL ASSESSMENT OF THE URBAN PARTICULATE PROBLEM

Volume IV - Birmingham

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA 22161

EPA-450/3-76-026b

NATIONAL ASSESSMENT OF THE URBAN PARTICULATE PROBLEM

Volume IV

Birmingham, Alabama

FINAL REPORT

by

David A. Lynn

Frank Record, Project Director

GCA/Technology Division
Burlington Road
Bedford, Massachusetts 01730

Contract No. 68-02-1376, Task Order No. 18

EPA Project Officer: Thompson G. Pace

Prepared for

ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

June 1976

This final report was furnished to the Environmental Protection Agency by the GCA/Technology Division in fulfillment of the requirements under Contract No. 68-02-1376, Task Order No. 18. The contents of this report are reproduced herein as received from the contractor. The opinions, findings and conclusions are those of the authors and not necessarily those of the Environmental Protection Agency.

FOREWORD

This document is part of a 16-volume report assessing the urban particulate problem, which was conducted by GCA/Technology Division for EPA.

This particular document is one of the 14 single city volumes that provide working summaries of data gathered in the 14 urban areas during 1974 to support an assessment of the general nature and extent of the TSP problem nationwide. No attempt was made to perform detailed or extensive analyses in each urban area. Rather, the city reports are intended as a collection of pertinent data which collectively form a profile of each urban area. This, in turn contributes to a comparative analysis of data among the 14 areas in an attempt to identify general patterns and factors relating to attainment of the TSP problem nationwide. Such an analysis has been made in Volume I of the study-National Assessment of the Urban Particulate Problem-National Assessment. The reader is referred to this volume as the summary document where the data is collectively analyzed.

This and the other 13 city reports are viewed primarily as working documents; thus, no effort was made to incorporate all the reviewer's comments into the text of the report. The comments were, however, considered during the preparation of Volume I and are included herein in order to alert the reader to different points of view. The 16 volumes comprising the overall study are as follows:

Volume	I - National Assessment of the Urban Particulate Problem
Volume	II - Particle Characterization
Volume	III - Denver
Volume	IV - Birmingham
Volume	V - Baltimore
Volume	VI - Philadelphia
Volume	VII - Chattanooga
Volume	IX - Oklahoma City
Volume	X - Seattle
Volume	XI - Cincinnati
Volume	XII - Cleveland
Volume	XIII - San Francisco
Volume	XIV - Miami
Volume	XV - St. Louis
Volume	XVI - Providence

Reproduced from best available copy.

CONTENTS

		Page
Foreword		iii
List of Figures		v
List of Tables		viii
Acknowledgments		x
Executive Summary		xi
Reviewers' Comments		xiv
Sections		
I	Introduction	1
II	Analyses	17
III	Summary and Conclusions	52
Appendixes		
A	Supplementary Information	56
B	Particle Characterization	69

LIST OF FIGURES

No.		Page
1	Location of Metropolitan Birmingham AQCR and Jefferson County	2
2	Average Number of Stagnation Days Per Year as Identified by the National Weather Service High Pollution Potential Advisory (HAPPA) Program	3
3	Jefferson County Monitoring Network	6
4	1974 Geometric Mean TSP Levels	7
5	Trend in TSP Levels at North Birmingham Site	8
6	Trend in TSP Levels at Downtown Site	9
7	Trend in TSP Levels at West End Site	10
8	Composite Seasonal TSP Patterns for 1974	11
9	Daily TSP Values at North Birmingham, Leeds, and Downtown Sites	13
10	Daily TSP Values at Fairfield and Bessemer Sites	14
11	Weekly Pattern of TSP Levels at North Birmingham Site	15
12	Weekly Pattern of TSP Levels at Downtown Site	16
13	Location of Major Point Sources Listed in Table 3	21
14	East Thomas Hi-Vol Site, Illustrating Typical 6-Foot High Mounting	29
15	Emissions Limitations for Fuel Combustion Operations	34
16	General Process Weight Regulations	35

LIST OF FIGURES (continued)

No.		Page
17	TSP Versus Wind Direction at Leeds Site	42
18	TSP Versus Wind Direction at West End Site	43
19	TSP Versus Wind Direction at Huffman Site	44
20	TSP Versus Wind Direction at Bessemer Site	46
21	TSP Versus Wind Direction at Fairfield Site	47
22	TSP Versus Wind Direction at East Thomas Site	48
23	TSP Versus Wind Direction at North Birmingham Site	49
24	TSP Versus Wind Direction at Tarrant City Site	50
25	TSP Versus Wind Direction at Downtown Site	51
A-1	Trend in TSP Levels at Bessemer Site	58
A-2	Trend in TSP Levels at Leeds Site	59
A-3	Trend in TSP Levels at Mt. Brook Site	60
A-4	Trend in TSP Levels at Tarrant City Site	61
A-5	Trend in TSP Levels at Woodlawn Site	62
A-6	Historical Trend in Annual Rainfall	63
A-7	Historical Trend in Annual Heating Demand	64
A-8	Seasonal Pattern of Days With Precipitation	65
A-9	Seasonal Pattern of Precipitation in Inches	66
A-10	Seasonal Pattern in Average Wind Speed	67
A-11	Seasonal Pattern in Heating Demand	68
B-1	Cumulative Size Distributions for Three Particle Types, Downtown Site, Birmingham, October 14, 1974	89

LIST OF FIGURES (continued)

No.		Page
B-2	Cumulative Size Distributions for Three Particle Types, North Birmingham Site, Birmingham, October 26, 1974	90
B-3	Cumulative Size Distributions for Three Particle Types, North Birmingham Site, Birmingham, November 1, 1974	91

LIST OF TABLES

No.		Page
1	NEDS Emission Summary for Jefferson County (Circa 1972)	18
2	Fugitive Source Emissions Estimates	19
3	Major Point Sources of Particulate Matter	20
4	Fuel Usage by Number of Dwelling Units, Jefferson County	24
5	Fuel Usage by Industry, Birmingham SMSA	24
6	Sampling Site Description and Land Use Characteristics	27
7	Jefferson County Coke Oven Regulation	37
8	Jefferson County Emissions From SIP (Tons Per Year)	40
A-1	Sampling Site Reference Data	57
B-1	Meteorological Data on Selected Sampling Days (Municipal Airport, Birmingham)	73
B-2	Annual Average Concentrations of Sulfate and Nitrate Ions at the Birmingham, Alabama, NASN Site No. 010380003 ($\mu g/m^3$)	75
B-3a	Results of Filter Analyses for Selected Sites in Birmingham and Vicinity (Downtown Aux.)	76
B-3b	Results of Filter Analyses for Selected Sites in Birmingham and Vicinity (No. Birmingham Aux.)	77
B-3c	Results of Filter Analyses for Selected Sites in Birmingham and Vicinity (West End)	78
B-3d	Results of Filter Analyses for Selected Sites in Birmingham and Vicinity (Mountain Brook and Leeds)	79

LIST OF TABLES (continued)

No.		Page
B-4	Composite Summary of Filter Analyses for Selected Sites in Birmingham and Vicinity	80
B-5	Results of Replicate Analyses of Birmingham Filters	81
B-6a	Results of Filter Analyses for Trends at NASN Site No. 010380003 in Birmingham (1970)	82
B-6b	Results of Filter Analyses for Trends at NASN Site No. 010380003 in Birmingham (1971)	83
B-6c	Results of Filter Analyses for Trends at NASN Site No. 010380003 in Birmingham (1972)	84
B-6d	Results of Filter Analyses for Trends at NASN Site No. 010380003 in Birmingham (1973)	85
B-6e	Results of Filter Analyses for Trends at NASN Site No. 010380003 in Birmingham (1974)	86
B-7	Composite Summary of Filter Analyses for NASN Sites in Birmingham and Vicinity (By Year)	87
B-8	Citywide Composite Summary of Filter Analyses in Birmingham	88
B-9	Detailed Physical Examination: Downtown, Birmingham, October 14, 1974	92

ACKNOWLEDGMENTS

GCA/Technology Division wishes to sincerely thank those persons and organizations who made significant contributions to this effort. On-going project supervision was provided by Thompson G. Pace of EPA's Control Programs Development Division. The case study in Birmingham was greatly assisted by the cooperation and helpfulness of the staff of the Jefferson County Department of Health, particularly Barry Robison, Henry Burnett, James Carroll, Kenneth Hall and C. R. Dillard.

EXECUTIVE SUMMARY

Birmingham, in Jefferson County, Alabama, is a heavy industrial city in a shallow valley at the southwestern end of the Appalachian Mountains. Generally southern and warm, though not subtropical, Birmingham is in the area where major air stagnations are most frequent.

AIR QUALITY LEVELS AND TRENDS

Eleven of the 13 hi-vol sites in the county exceed the annual standard in 1974 frequently, with levels ranging from 84 to 144 $\mu g/m^3$. Three of the sites exceed the 24-hour standard very frequently, and daily loadings in the range 400 to 500 $\mu g/m^3$ do occur. At all but one of the sites in violation, however, levels have been declining significantly since the mid-1960's, and especially since the early 1970's. Decreases of about 50 percent have occurred at the industrial/residential sites that still have the highest levels.

SOURCES AND EMISSIONS

Particulate emissions in Jefferson County are estimated at over 200,000 tons per year. Nearly 90 percent of this total is from industrial processes, with the remainder mostly from fuel combustion. The fuel consumption contribution is low because of the moderate climate and the extensive use of natural gas, and because the electric generating capacity is located outside the County.

The industrial emissions are primarily from the steel industry, especially open hearth, coke ovens, and associated foundries, and from Portland

cement plants. Emissions from each of these categories have been declining significantly — the open hearths through economic replacement, the others because of regulatory controls.

METEOROLOGY AND CLIMATOLOGY

The Birmingham area suffers from quite adverse dispersion conditions. It is located in the area of the eastern United States where stagnant high pressure systems are the most frequent, and in addition the valley topography increases the frequency and severity of nocturnal radiation inversions. Precipitation is moderately heavy (53 inches per year) and plays a major role in determining day-to-day variations in TSP levels.

REGULATIONS AND COMPLIANCE

The Jefferson County Health Department has enforced pollution control regulations since the passage of state enabling legislation in Alabama in 1971. The general process weight regulation, and specific regulations for small foundries and cotton gins, are on the more stringent side of the range of regulations studied. Coke ovens are controlled with a regulation establishing standards of maintenance and good practice. The fuel combustion regulation is generally typical of those surveyed, though less stringent in the case of small units. As used in Jefferson County currently, it has the effect of converting most sources to gas, so it is unlikely that a tightening of the fuel combustion emission limitations would have any significant effect.

MONITORING NETWORK DESIGN

The hi-vol monitoring network is adequately representative of the various areas of Birmingham and environs, and involves extensive extra monitoring for episode surveillance purposes. The network includes a large proportion of sites in areas between industrial and residential neighborhoods,

which tends to overemphasize the degree to which Birmingham violates the national standards in comparison with other cities. A unique circumstance of the network is the generally low heights at which the hi-vols are operated (most at 6 feet); this also tends to lead to artificially high TSP levels in comparison with many other cities.

FACTORS INFLUENCING AIR QUALITY

The principal factor in Birmingham's general failure to meet the standard is simply the massive industrial emissions total, coupled with the relatively few years of actual control efforts. Adverse meteorology conditions make meeting the standards more difficult, and in particular cause extreme short-term peak levels. In addition, the aggregate assessment of the county's compliance is affected by a high proportion of industrial sites, and the generally low height of sampler operations, both of which tend to indicate levels higher than otherwise.

REVIEWERS' COMMENTS

The draft report for each city was submitted to interested EPA, state, and local officials for comment on the contents and findings. Comments of an editorial nature were reconciled; comments of a substantive nature which reflect differences of opinion were compiled and are presented below:

> The Executive Summary and Section III "Summary and Conclusions" states that the major reason sites in Birmingham are not meeting the national standard is simply the enormous industrial emissions which have not been sufficiently reduced in a 3-year period. Although this is a factor, we feel that stressing the length of time or degree of control of emissions as the most important components of the problem fails to give sufficient weight to other significant factors brought out in the study, such as height of samplers, industrial siting of samplers, meteorology and urban background. These components will present formidable obstacles to attaining standards regardless of the effectiveness and/or implementation period of the control program.
>
> Information contained in this section and Table 1 probably reflect the information made available at the time of investigation. Since that time, the emission inventory has been updated and revised. Below is a revised emission inventory summary.

EMISSIONS FOR JEFFERSON COUNTY
(Circa 1972)

	Emissions, tons/year	Percent of total
Fuel combustion	14,172.2	9.2
Residential[a]		
Commercial[a]		
Electric generation	13.0	0.0
Industrial	14,159.2	9.2
Industrial processes[b]	138,747.1	83.9
Solid waste disposal[c]	49.2	
Transportation	1,665.8	1.1
Miscellaneous	1,033.7	0.8
Total	154,718.0	

[a]These categories were summarized under "miscellaneous."

[b]All categories under "Industrial processes" were not separated.

[c]All categories under "Solid waste disposal" were combined.

Table 2 summarizes the fugitive source emissions estimates which were based on the results of an EPA study. It is my opinion that unless the details of computation including the breakdown of this information into some sort of geographical distribution is made available that the section be eliminated. An estimate of 216,040 tons a year of fugitive dust sources from agricultural tilling, unpaved roads, air strips, and construction sites is questionable and certainly should not be included without supporting documentation. Also, no reference made to fugitive emissions of particulates from point sources. I have no doubt that the fugitive emissions are significant in Jefferson County but I do hesitate to include such estimates without substantial supporting information.

Page 20 - Table 3 as prepared is rather confusing. I would recommend that the companies be identified and that similar companies be grouped together. Also, the emission "after final compliance" for the first entry (Open Hearths) should be zero. Also it should be noted that the 172 tons/year for the second

entry represents the replacement of the open hearths by the "Q-BOP" oxygen process.

Page 22 - Paragraphs entitled Foundries - states that some smaller, older installations have closed. To our knowledge there have been no foundries closed in Jefferson County due to environmental regulations. Several small foundries have changed from cupola melting to induction furnace melting which achieves compliance with the rules and regulations without the installation of control equipment but we are not aware of any closures as a result of environmental requirements.

Page 36 - Paragraph entitled Institutional Framework states that no state or local authority had legal authority to institute an air pollution program until 1971. This is not entirely correct. The Alabama legislature did enact an Air Pollution Control Law in 1969 that pre-empted local agencies from any action in air pollution control and was relatively ineffective at the state level. It was superseded in 1971 by the present legislation.

Page 53 - Paragraph entitled Regulations - Compliance - last sentence states that about half the major point sources are in compliance with the balance on compliance schedules running through May 1976 at the latest. This information was probably correct at the time of the preparation of this report in 1975, but does not represent the situation as it exists today in Jefferson County. As of January 1, 1976, there are only 11 point source facilities in Jefferson County that are not in compliance with the rules and regulations. This represents approximately about 10 percent of the point source facilities that are reportable to the EPA.

SECTION I

INTRODUCTION

NATURE OF THE BIRMINGHAM AREA

The Metropolitan Birmingham AQCR consists of 14 counties in west-central Alabama (see Figure 1). The urban focus is Birmingham, in Jefferson County, the State's largest city and a major industrial center of the entire southeast. The primary focus of this study has been Jefferson County, including not only Birmingham proper but also the immediately surrounding cities and towns and the more distant city of Leeds.

Birmingham is located in Jones Valley at the southwestern end of the Appalachian Mountain Range, about 150 miles southwest of Chattanooga. The valley is one of several northeast-southwest valleys formed as the mountains spread out onto the coastal plateau. The ridge of hills to the northwest, and Red Mountain to the southeast, are low enough to permit the spread of urbanization, but high enough (600 feet) to significantly affect the dispersion of pollutants, causing wind restriction and channeling, mountain-valley drainage flows, and an increase in the frequency and severity of nocturnal radiation inversions.

On a larger scale, the Birmingham area also suffers from a high frequency of general atmospheric stagnation conditions; as seen in Figure 2, it lies in the same area of maximum occurrance as do Chattanooga and the Smoky Mountains. It averages about 6 days per year with conditions severe enough for a National Weather Service pollution potential forecast.

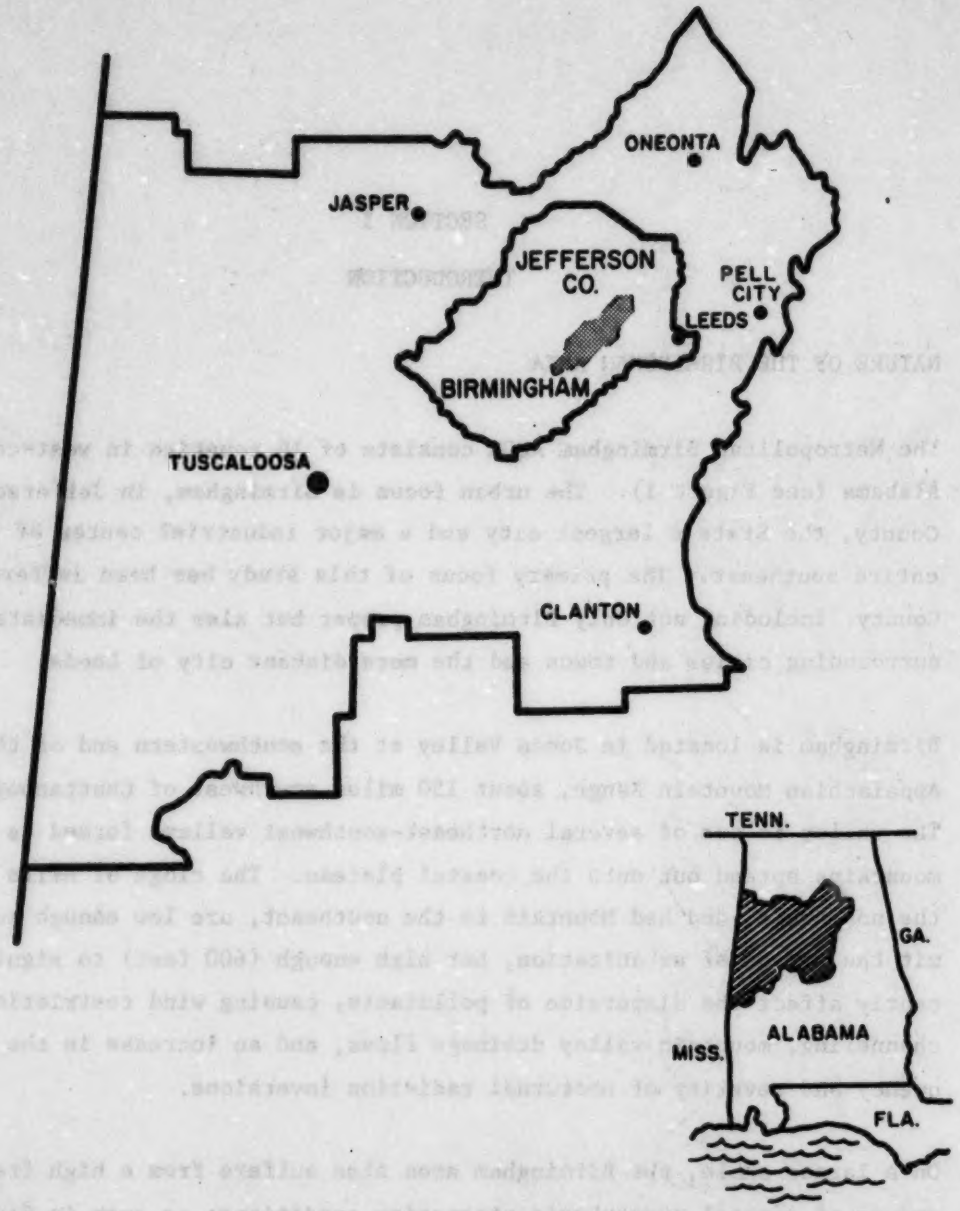

Figure 1. Location of Metropolitan Birmingham AQCR and Jefferson County

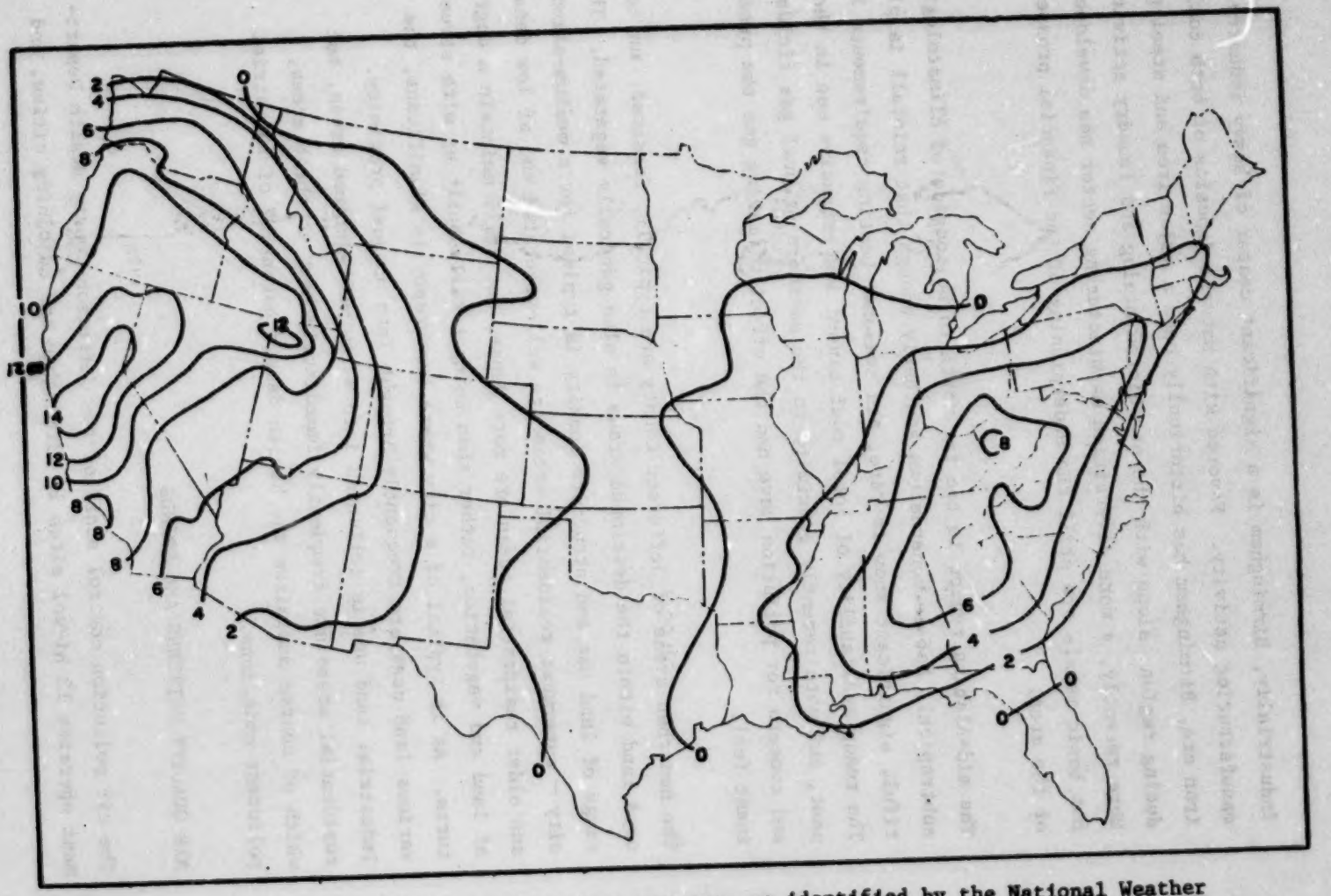

Figure 2. Average number of stagnation days per year as identified by the National Weather Service High Pollution Potential Advisory (HAPPA) program[1]

Industrially, Birmingham is a significant center of heavy industry and manufacturing activity. Favored with natural deposits of both coal and iron ore, Birmingham has historically been a major iron and steel producing region, along with the associated mining and foundry activity. More recently, a more diversified manufacturing sector has developed, but basic metals are still the underpinning of the financial prosperity of the area.

The mid-Alabama region is too far north to be considered climatologically subtropical, but is nonetheless southerly enough that rainfall is plentiful, significant snow is rare, and seasonal heating requirements low. The ready availability of local coal caused its extensive use in the past, but more recently proximity to the southern natural gas fields and concern for pollution have had the effect of making gas the predominant fuel.

The nonurban areas of Jefferson County are typically forested, and unused land within the developed areas is also generally vegetated. The range of land use and structure density is typical for a medium-sized city — outermost residential areas are well-vegetated and of low density, and older residential areas are more dense, but still maintain a degree of land and vegetation, rather than being totally built up with structures. As is typical of a city where topography is significant, the various land uses are frequently brought into unusual proximity. Industrial land use is collected into a few well-defined areas, but residential areas are frequently immediately next to these areas, which of course maximizes the health damage potential of industrial pollutant emissions.

AIR QUALITY PATTERNS AND TRENDS

The air pollution control staff of the Jefferson County Health Department operates 12 hi-vol sites in Birmingham and adjoining cities, and

one additional in the town of Leeds in the eastern part of the County. These sites are identified on the maps in Figures 3 and 4, with the geometric mean concentration recorded at each site for 1974. Levels at most of the sites are well above the 75 $\mu g/m^3$ primary standard; the only two sites meeting the standard are the Huffman Road site in the far northeast and the Mountain Brook site to the southeast. The highest levels are at the North Birmingham site and the Leeds site (not shown) — 144 and 143 $\mu g/m^3$, respectively. The three sites along the northwestern side of the valley — East Thomas, North Birmingham, and Tarrant City — are in the 125 to 145 $\mu g/m^3$ range, while the majority of the sites through the center of the valley are in the 80 to 100 $\mu g/m^3$ range.

Although the 1974 TSP levels exceed the standards significantly, the trend over time has been very favorable; with the exception of the site at Leeds, levels at all the sites are down significantly over the years since 1971, and down dramatically since the mid-1960s. Figures 5, 6, and 7 illustrate typical trends at three sites, presented as monthly arithmetic means, with a smoothed trend line. Levels at the industrial North Birmingham site (Figure 5) have fallen from around 300 $\mu g/m^3$ in the late 1960s to the 150 $\mu g/m^3$ vicinity during 1974; the Downtown CBD site (Figure 6) and the West End residential site (Figure 7) show similar decreases of roughly 50 percent since 1970. The Leeds site has not shown a decrease in average TSP levels. In operation since August 1972, monthly average levels at the Leeds site have ranged from 111 to 190 $\mu g/m^3$, with no trend evident. Trend plots similar to Figures 5 to 7 are presented for other sites in the Appendix.

The particulate levels in the Birmingham area did not show any pronounced seasonal pattern during 1974, nor have they in recent years. Figure 8 presents the pattern of composite monthly averages (arithmetic) for 1974, for the entire network and for the six "episode" sites, which sample more frequently. In either case, mid-summer and October were clearly high, with September distinctly low. Included in the Appendix

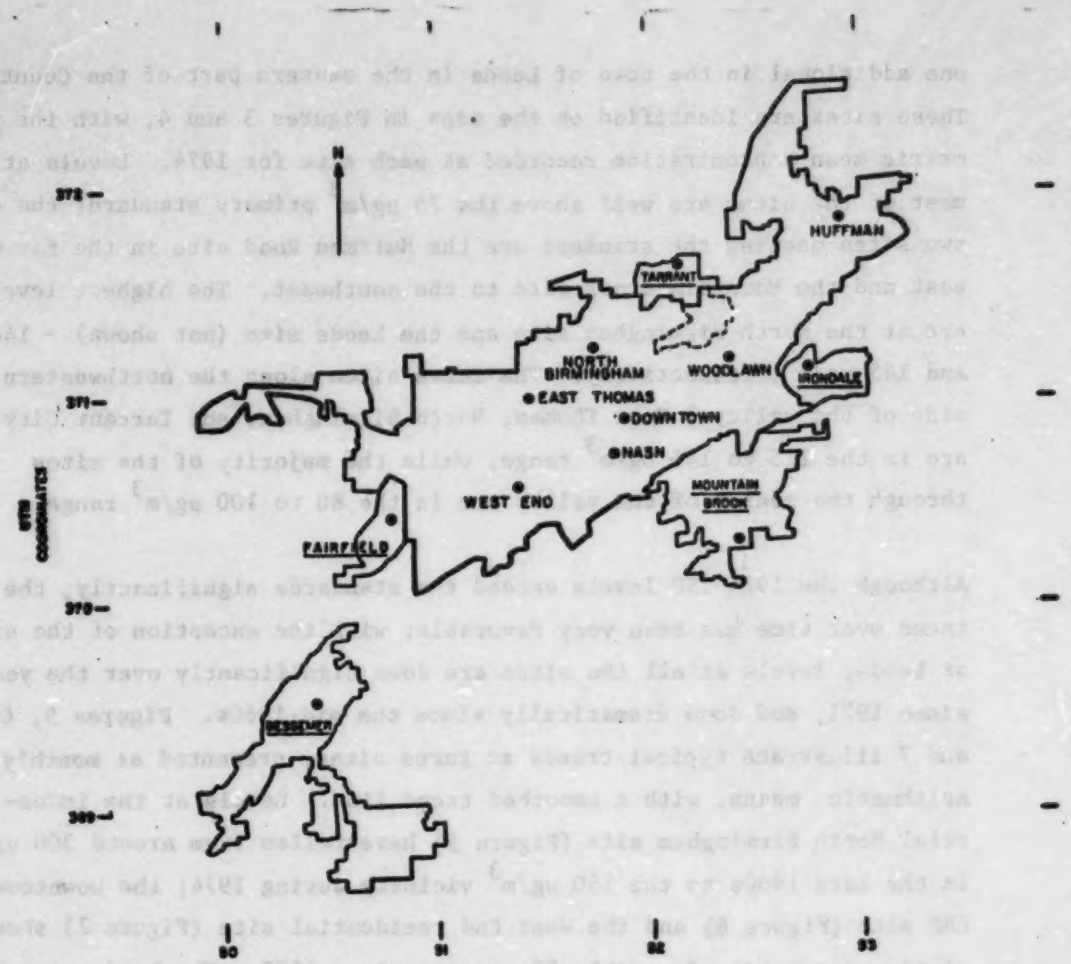

Figure 3. Jefferson County monitoring network

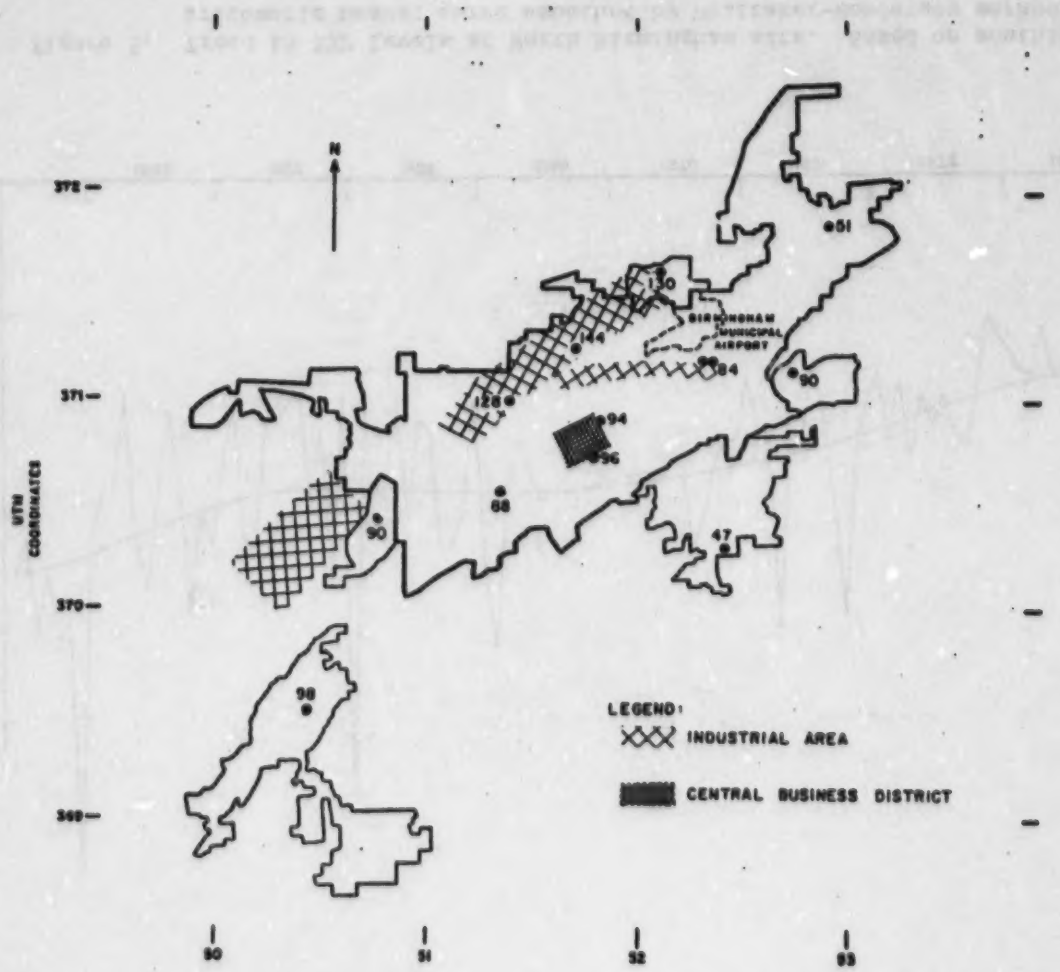

Figure 4. 1974 Geometric mean TSP levels

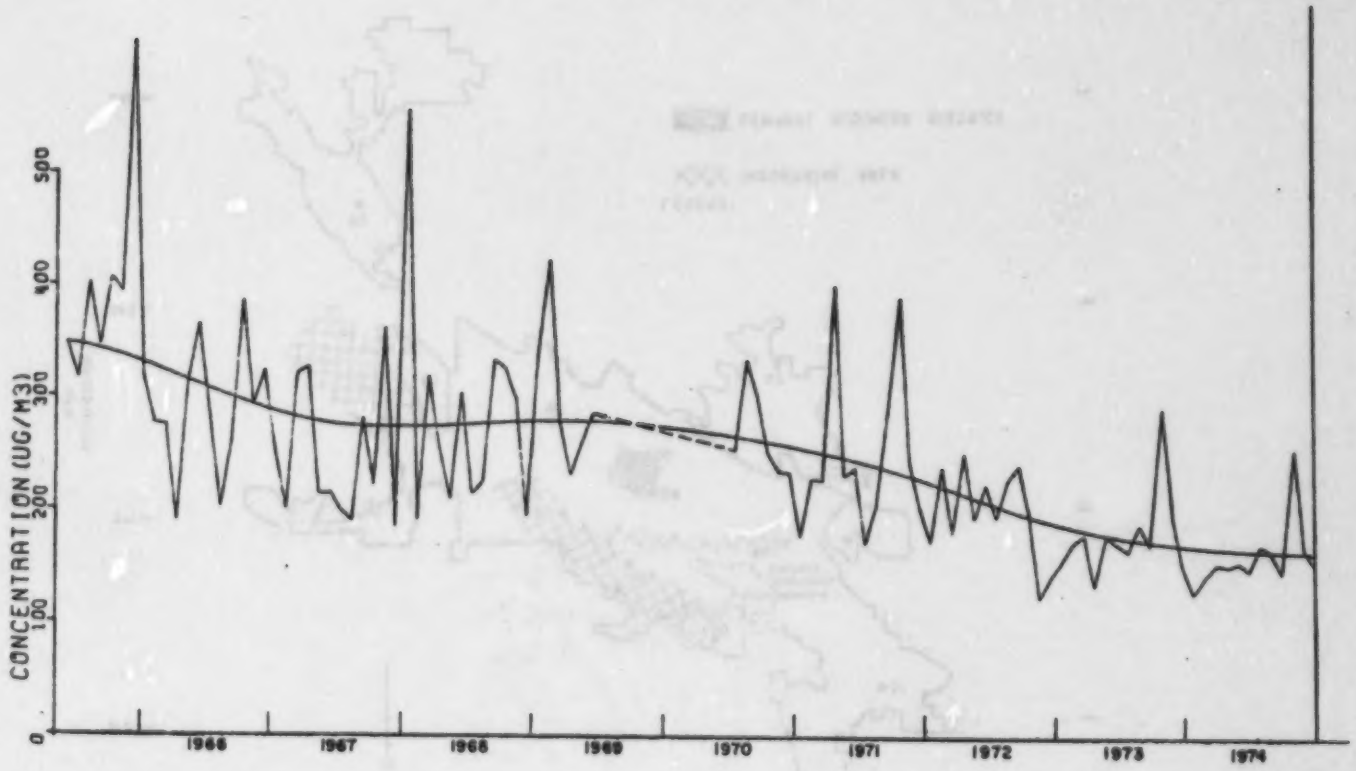

Figure 5. Trend in TSP levels at North Birmingham site. Based on monthly arithmetic means; curve smoothed by Whittaker-Henderson method

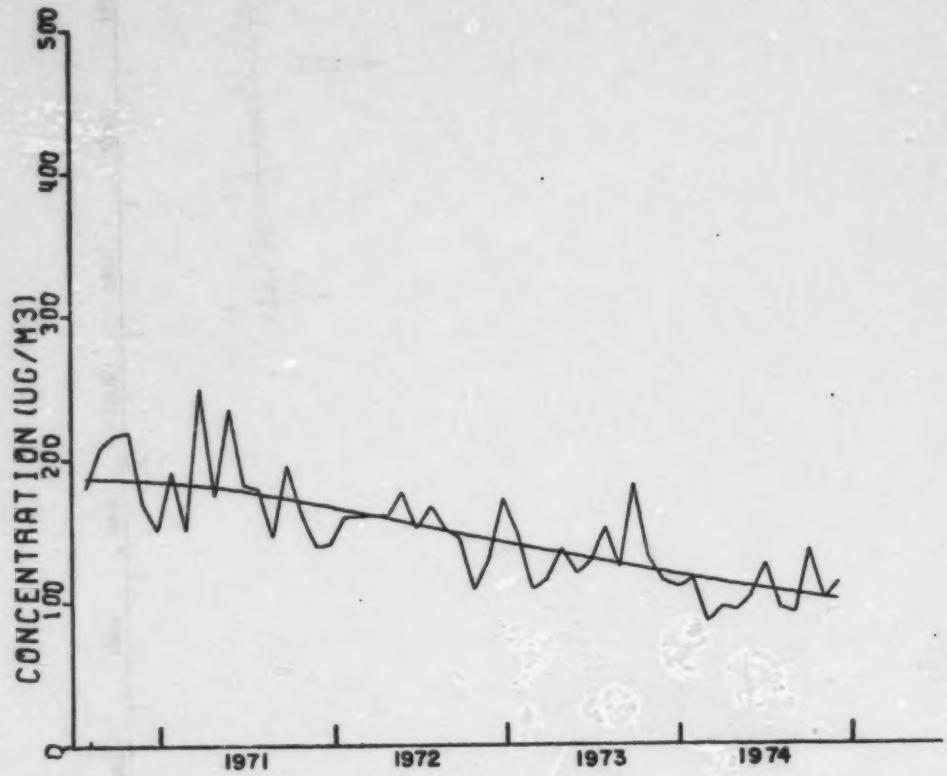

Figure 6. Trend in TSP levels at Downtown site. Based on monthly arithmetic means; curve smoothed by Whittaker-Henderson method

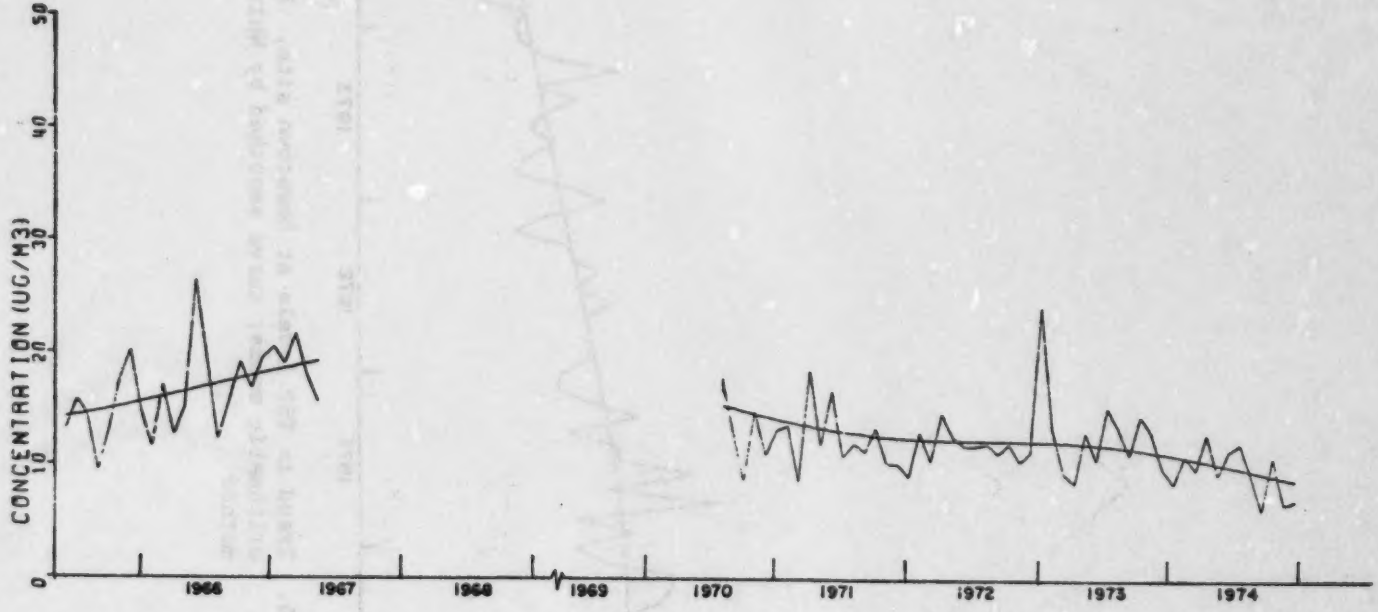

Figure 7. Trend in TSP levels at West End site. Based on monthly arithmetic means; curve smoothed by Whittaker-Henderson method

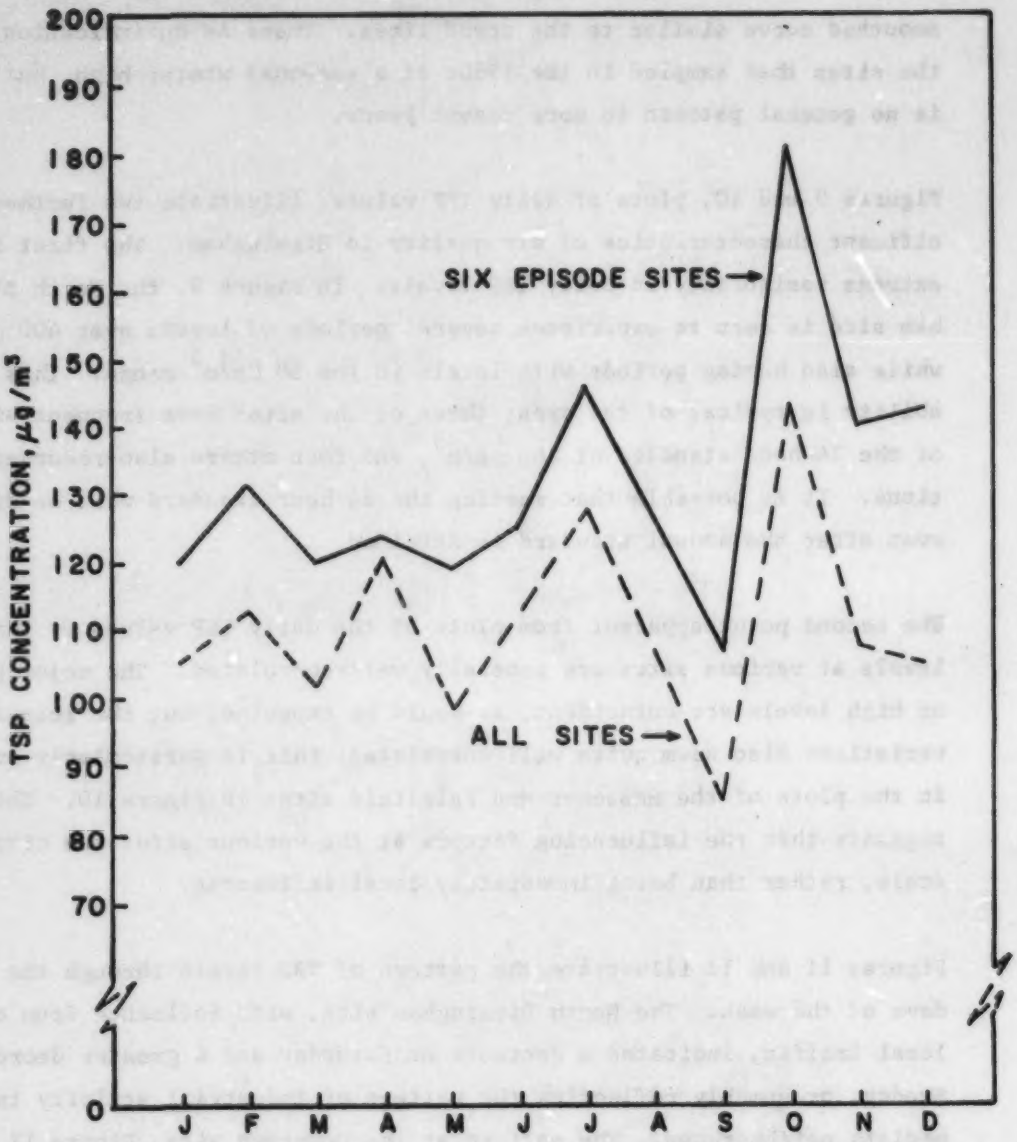

Figure 8. Composite seasonal TSP patterns for 1974

are plots with the seasonal pattern for each site, in the form of a smoothed curve similar to the trend lines. There is an indication at the sites that sampled in the 1960s of a seasonal winter high, but there is no general pattern in more recent years.

Figures 9 and 10, plots of daily TSP values, illustrate two further significant characteristics of air quality in Birmingham. The first is the extreme variability in daily TSP levels. In Figure 9, the North Birmingham site is seen to experience several periods of levels over 400 $\mu g/m^3$, while also having periods with levels in the 50 $\mu g/m^3$ range. This variability is typical of the area; three of the sites have frequent violations of the 24-hour standard of 260 $\mu g/m^3$, and four others also recorded violations. It is possible that meeting the 24-hour standard will be difficult even after the annual standard is attained.

The second point apparent from plots of the daily TSP values is that the levels at various sites are generally well-correlated. The major periods of high levels are coincident, as would be expected, but the less extreme variations also seem quite well correlated; this is particularly evident in the plots of the Bessemer and Fairfield sites in Figure 10. This strongly suggests that the influencing factors at the various sites are citywide in scale, rather than being immediately local influences.

Figures 11 and 12 illustrate the pattern of TSP levels through the various days of the week. The North Birmingham site, with influence from only very local traffic, indicates a decrease on Saturday and a greater decrease on Sunday, presumably reflecting the pattern of industrial activity in the immediate neighborhood. The pattern at the Downtown site, Figure 12, indicates a more uniform change from weekday to weekend, presumably reflecting the influence of CBD traffic as well as the overall industrial emissions pattern.

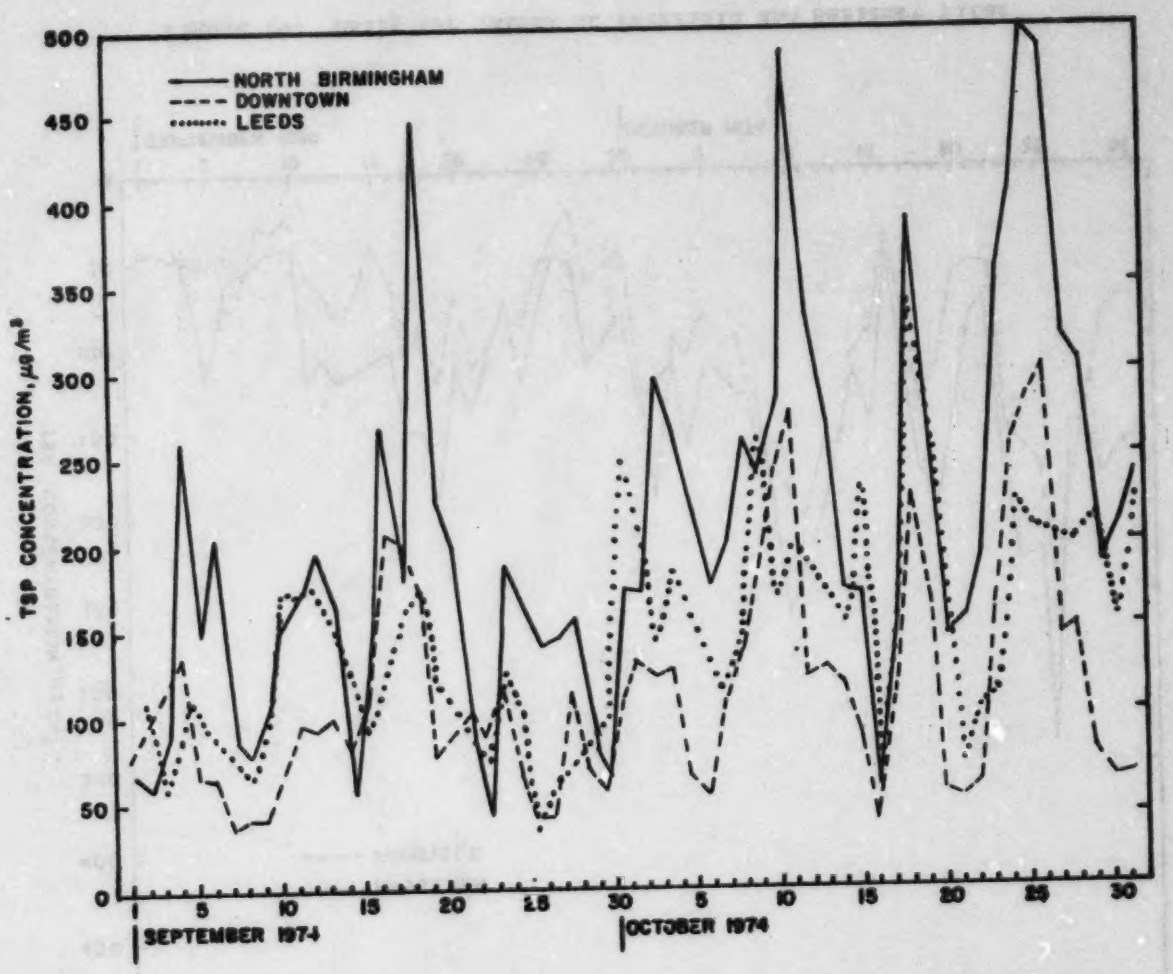

Figure 9. Daily TSP values at North Birmingham, Leeds, and downtown sites

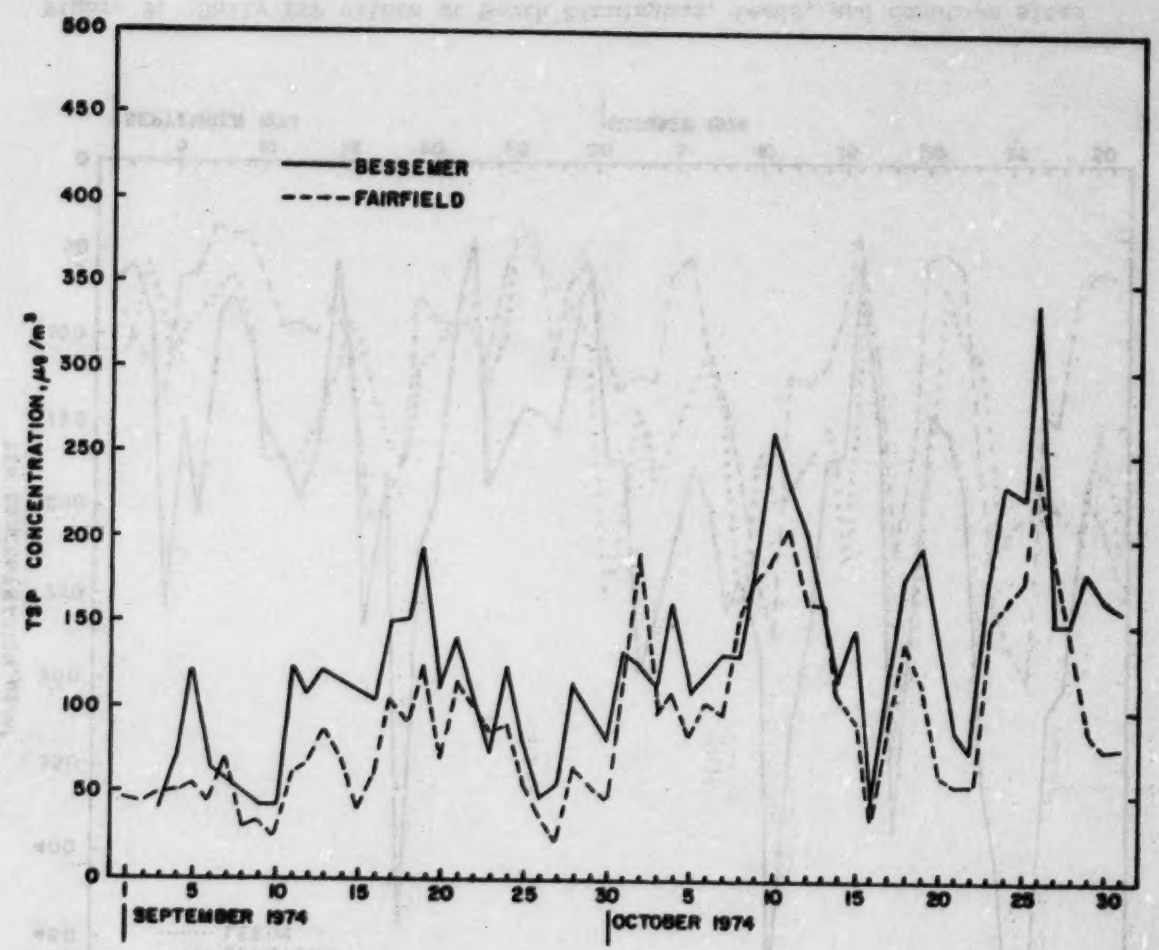

Figure 10. Daily TSP values at Fairfield and Bessemer Sites

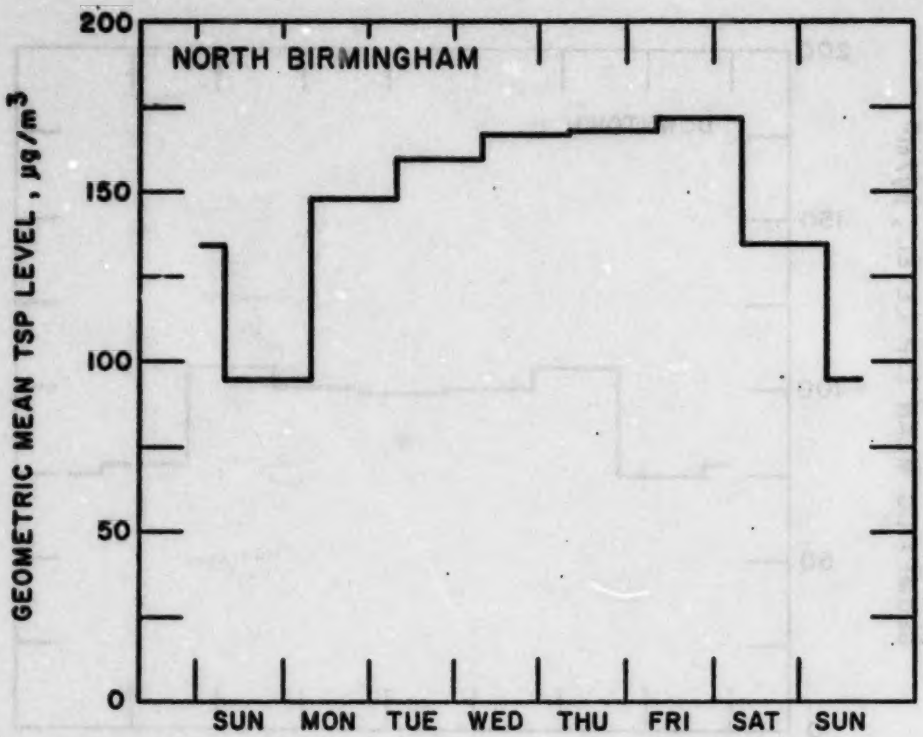

Figure 11. Weekly pattern of TSP levels at North Birmingham site

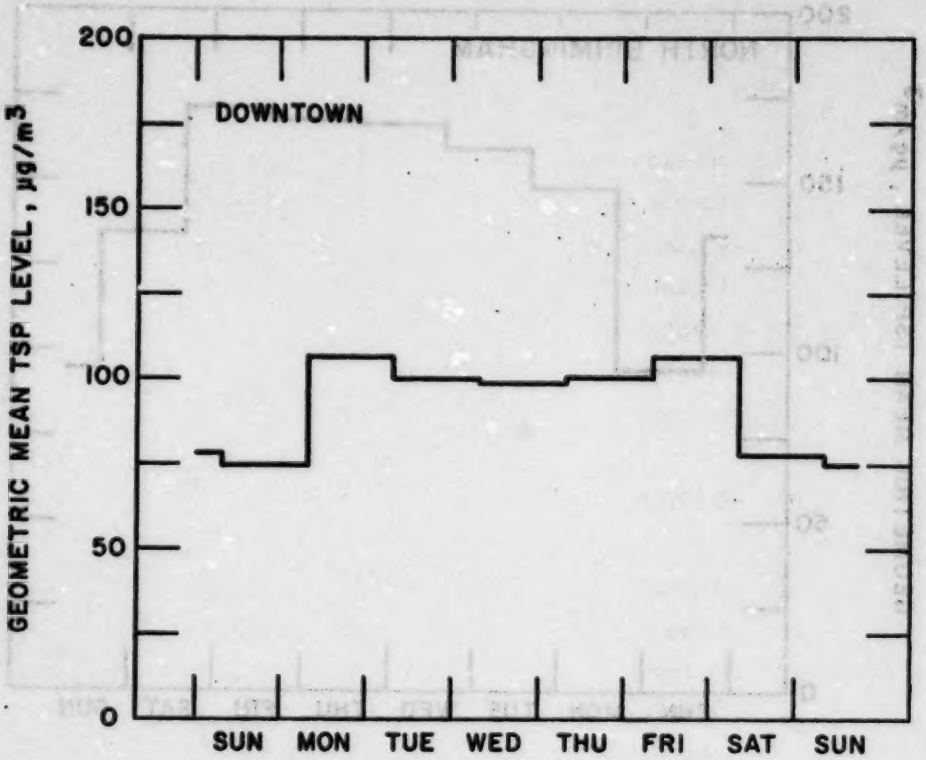

Figure 12. Weekly pattern of TSP levels at Downtown site

SECTION II

ANALYSES

This Section considers the various factors that may reasonably be expected to influence particulate levels, providing relevant information and presenting the analyses that have been undertaken to assess the relative significance of the various factors. In the case of Birmingham, the following factors are considered in turn in the subsequent text: sources and emissions, the monitoring network, meteorology and climatology, and regulations and control.

SOURCES AND EMISSIONS

The predominant source of particulate emissions in Jefferson County is unquestionably the iron and steel industry. Table 1 presents a summary of the emission inventory currently in the NEDS data bank; it typically represents 1972 information and is generally consistent with the data maintained by the Jefferson County agency staff. The industrial process category accounts for about 90 percent of the total, with the vast majority of that in the two industry groups primary metals and mineral products, the latter primarily cement mills. The only significant non-process source category is industrial fuel combustion, amounting to 7.5 percent of the table. Fuel combustion for space heating, which is frequently responsible for a major share of particulates, is minimized in Birmingham by the relatively mild climate and the prevalence of natural gas usage. The electric generating plants for the area are located at some distance outside the county; in the NEDS inventory for the entire AQCR, power generation emissions are comparable in magnitude to the industrial process share.

Table 1. NEDS EMISSION SUMMARY FOR JEFFERSON COUNTY (Circa 1972)

	Emissions, tons/year		Percent of total	
Fuel Combustion		15,701		7.8
Residential	421		0.2	
Electric generation	13		0.0	
Industrial	15,107		7.5	
Commercial-Institutional	160		0.1	
Industrial Processes		180,290		89.2
Primary metal	152,317		75.4	
Secondary metal	3,882		1.9	
Mineral products	22,406		11.1	
Other	1,685		0.8	
Solid Waste Disposal		2,674		1.3
Open burning	2,[illegible]0		1.1	
Commercial-Institutional	230		0.1	
Industrial	234		0.1	
Transportation		3,046		1.5
Miscellaneous		427		0.2
TOTAL		202,138		

In addition to the source categories listed in Table 1 and discussed above, some additional emissions are undoubtedly generated from the sources that have come to be called fugitive dust sources. An EPA study[2] has estimated emissions from several such sources for the entire U.S. on a county-by-county basis; the estimates for Jefferson County and the Metropolitan Birmingham AQCR are presented in Table 2. These estimates are comparable in magnitude to the totals of the conventional inventories. In the context of this project and report, they are seen, intuitively, as being quite high and difficult to reconcile with conventional presumptions. For the present, they are merely presented for completeness, pending a thorough assessment.

Table 2. FUGITIVE SOURCE EMISSIONS ESTIMATES

Source	Emissions (tons/year)	
	Jefferson County	Birmingham AQCR
Unpaved roads	193,000	943,000
Dirt airstrips	0	0
Construction	23,000	75,320
Land filling	40	1,790
Total fugitive	216,040	1,003,610
Conventional inventory	202,138	662.845

The major conventional point sources of particulate emissions are summarized in Table 3, and are located geographically on the map in Figure 13. From Tables 1 and 3, it is apparent that the major contributors to the particulate problem in Birmingham are the open hearth steel furnaces, coke production, foundries, cement plants, and fuel combustion. The status of these sources and trends in the emissions are most easily considered in the context of these categories.

Table 3. MAJOR POINT SOURCES OF PARTICULATE MATTER

Type of source	Emissions (tons/year) 1972	Emissions (tons/year) 1 Jan. 1975	Compliance status (7/1/75)	After final compliance	
				Emissions (tons/year)	% reduction
Steel (open hearths)	10,592	10,592	Consent order thru 5/76	535	95
Steel (open hearths)	16,803	7,468	In compliance since 6/75	172	99.0
Mineral wool plant	4,340	4,340	In compliance since 5/75	1,008	77
Cement manufacture	3,635	3,635	Variance till 5/76	553	85
Cast iron pipe	2,433	2,433	In compliance since 6/75	123	95
Coke oven operation	4,729	1,879	Variance till 5/76	1,658	65
Coke oven operation	2,206	1,754	Variance till 11/75	766	65
Cast iron pipe	1,970	1,602	In compliance 6/75	119	94
Coke oven operation	1,834	1,478	Variance till 5/76	653	66
Steel (sintering)	24,564	1,474	Evaluating compliance	807	97
Coke oven operation	1,701	1,395	Variance till 1/76 & 5/76	630	63
Cement manufacture	17,964	1,356	In compliance since 6/75	796	95
Cast iron pipe	1,485	1,229	In compliance since 4/75	577	61
Mineral wool plant	1,417	1,202	In compliance wince 5/75	147	90
Ferrosilicon production	429	429	Variance till 2/76	18	96
Cast iron pipe	448	420	Variance till 3/76	142	62
Aggregate production	1,347	315	In compliance	315	77
Cast iron products mfg.	3,840	227	Temporary permit	227	94
Cement manufacture	27,415	174	In compliance	174	99.3
Mineral wool plant	1,037	166	Variance till 5/76	129	88
Brass and grey iron foundry	883	119	In compliance	119	87
Slag processing	628	96	In compliance	96	85
Coke oven operation	677	90	In compliance	90	87
Total	132,377	43,873		9,854	92.6

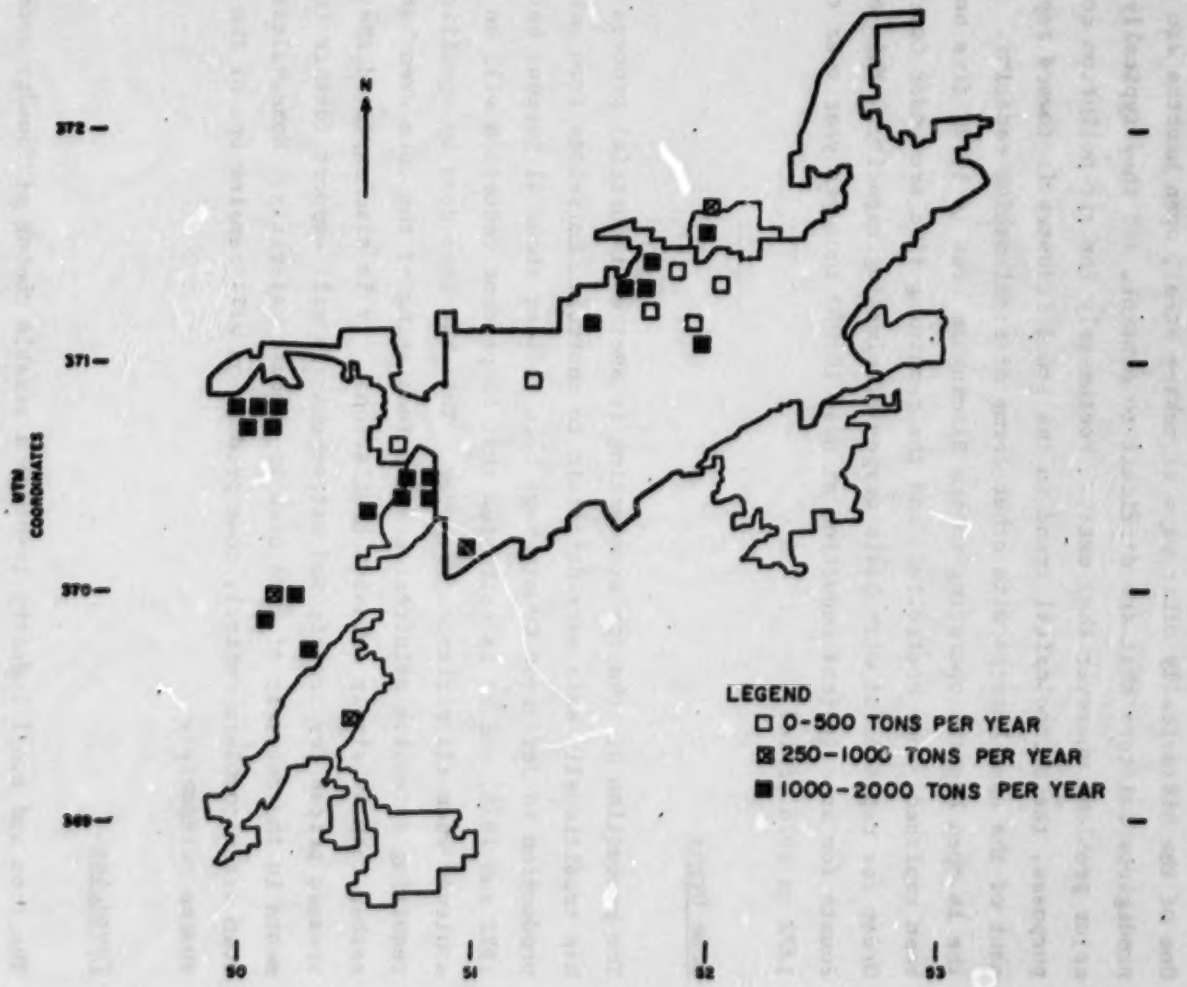

Figure 13. Location of major point sources listed in Table 3

Open Hearth Steel Furnaces

One of the historically older ways of making steel, open hearths are prodigious emitters that are difficult to control, and they typically are major problems wherever they exist. Fortunately for air pollution control purposes, the technological trend in the steel industry is toward replacement of the open hearths with other forms of steel-making capacity. Of the 14 open hearths operating in the Birmingham area in 1972, five have been replaced, four controlled, and the remaining five are under Court Order for replacement with basic oxygen steelmaking capacity. This accounts for an emissions reduction of over 16,000 tons per year over the 1972 to 1976 period.

Coke Ovens

The production of coke for steelmaking is another industrial process that has traditionally been very difficult to control. Emissions from coke production in Jefferson County have been reduced about 41 percent between 1972 and 1975, and it is estimated that 66 percent reduction will be achieved when all variances are over. This has been done by specifically requiring extensive maintenance and refurbishing of the coke oven batteries, rather than by simple emission limitations. It is also expected that increased prices for organic and petrochemicals will support further improvements in the recovery of coke oven by-product materials. Nonetheless, even after complete control, coke production will remaine one of the larger source categories.

Foundries

The iron and steel industry involves a sizable number of foundry operations of various sizes; in Birmingham, many foundries have been operating quite old equipment. In response to the process weight regulation for cupolas, larger foundries are generally installing baghouses; some smaller,

older installations have closed. Through the end of 1974, over 40 percent reduction has been achieved in foundry operations, and about 88 percent is expected ultimately when all variances are completed.

Cement Mills

Cement plants have reduced emissions dramatically. Of four cement mills operating prior to the pollution control program, one has closed (1971) and two others have added major electrostatic precipitator installations; these two have each reduced their emissions over 99 percent. The fourth cement mill is still uncontrolled. It is the reason for the very high levels at the hi-vol site in Leeds, which was placed within a few blocks to monitor the plant. The plant's current kiln is being replaced by a new, dry-process, kiln, not only for pollution control purposes but also because of the energy savings potential.

Fuel Combustion

As in many areas, the long-term trend in fuel usage has been, at least in the case of small users, away from coal to cleaner, more convenient, natural gas. Table 4 presents the changes in residential fuel use over the last 20 years; the proportion of housing units using gas, and also electricity, has increased dramatically, at the expense of coal and the always-small oil share. A similar pattern is very likely the case for commercial-institutional and smaller industrial fuel users. Fuel use by industry as a whole, however, followed an opposite pattern, through 1972, as seen in Table 5; oil and coal increased at the expense of gas and coke. (It should be noted that it is unclear how the data reference involved consider steel-owned coking operations.) Since 1971-1972, however, the trend in fuel use by all larger users has been away from coal because of the pollution control regulations. In response to the fuel combustion emission limitations, the vast majority of fuel users have changed to gas, with a few larger users maintaining a backup oil-burning capability. This has had, of course, a significant effect on emissions.

Table 4. FUEL USAGE BY NUMBER OF DWELLING UNITS, JEFFERSON COUNTY

	Number of dwelling units			Percent change 1950-1970
	1950	1960	1970	
Gas	52,000	139,000	178,000	+ 245
Oil	9,000	3,700	2,100	- 77
Coal	86,000	35,000	10,000	- 88
Electricity	560	1,600	11,400	+1940
Total	258,000	268,000	274,000	+ 6

Table 5. FUEL USAGE BY INDUSTRY, BIRMINGHAM SMSA

	1963	1972	Percent change
Coal (tons)	202,000	334,000	+66
Fuel oil (bbl)	592,000	892,000	+51
Gas (10^6 ft^3)	14,776	42,500	-15
Coke (tons)	1,902,000	862,900	-55

Area Sources

Because of the dominant influence of the massive industrial process emissions, area sources have not been the subject of major control efforts. Transportation emissions are estimated by the Jefferson County agency staff at about 1,660 tons per year, with all other, including solid waste disposal and residential, commercial, and institutional fuel combustion, at about 1,100 tons per year. Heating fuel combustion emissions are of course quite low because of the use of gas and the mild climate. In the Central Business District, the total area source emission density is about 40 tons per year per square mile; in the older residential area

near the West End monitoring site, it is about 15 tons per year per square mile. In contrast, the area surrounding the North Birmingham industrial site has an emission density of about 7,600 tons per year per square mile, of which only about 25 is from area sources.

NETWORK DESIGN AND MONITOR SITING

The effect of the hi-vol monitoring network itself on recorded TSP values, if any, is not a dominant effect in comparison to the effect of either emission levels or meteorology. However, there are some unusual features of the Jefferson County network that should be discussed prior to other topics, simply for convenience and coherence of discussion.

Among other monitoring activities, the air pollution staff of the Jefferson County Health Department operates a 13-site hi-vol network, as was illustrated in Figure 3. Several of these sites (North Birmingham, Tarrant City, Bessemer, West End, Woodlawn) have been operated at essentially the same location for many years – since 1965 by the present organization, and in some cases prior to that by ad hoc groups conducting studies of the Birmingham pollution problem.

The overall coverage of the network is adequate in terms of the various types of land use in the metropolitan Birmingham area. There are four CBD sites (Downtown and NASN in Birmingham, and the Bessemer and Irondale sites), two sites in old established residential areas (West End and Woodlawn), two sites in open, newer residential areas (Huffman and Mountain Brook), and the balance (six sites) are generally in or very near industrial areas. This high proportion of sites on the fringes of industrial areas is deliberate, in response to the SIP mandate to monitor in the areas anticipated to have the maximum levels, and in recognition of the health hazards involved when residential areas are immediately adjacent to heavy industrial activity. However, this conscientious policy

means that a large proportion of the sites will have high levels, and in comparison with other cities, Birmingham could appear in an unfavorable position.

Because of the frequency and severity of adverse meteorological conditions, the agency has developed an extensive monitoring program directed at surveillance of the short-term pollution episode problem. At a number of sites extra episode monitoring is conducted; as of late 1974, these sites were Downtown, North Birmingham, Fairfield, Leeds, Bessemer, and East Thomas. At these sites, an additional hi-vol is operated on an 8 a.m. to 8 a.m. cycle, so that at the beginning of each day, an up-to-the-hour sample is available for episode surveillance. If circumstances warrant, a third, auxiliary hi-vol is also operated, on a 2 p.m. to 2 p.m. cycle. Aside from the obvious benefits in terms of episode surveillance, this procedure provides a set of essentially-daily TSP observations at a number of stations, which constitutes an unusually rich data resource. The plots in Figures 9 and 10, for instance, and the conclusions they suggest, are possible only with the daily data from the episode stations. The major manpower commitment required by such a monitoring effort, however, has also necessitated some minor scheduling anomalies that require care in data interpretation; we'll return to these shortly.

A summary of the station siting characteristics and the land use surrounding each site is presented in Table 6; a tabulation of SAROAD codes, UTM coordinates, and similar detailed data is included in the appendix.

Probably the most apparent and unusual feature of the sampler siting data in Table 6 is the consistent low height of the hi-vols. With the exception of the NASN site, which is established in a typical NASN setting, the sites are all at 6-foot or 10-foot heights. The reason is mostly historical — the siting was initially done in the process of a special study as early as the 1950's,[3] and has been maintained since. The 6-foot

Table 6. SAMPLING SITE DESCRIPTION AND LAND USE CHARACTERISTICS

Site	1974 geo. mean	Predominant influence	Sampler height (ft)	Immediate site location	Nearby land use
North Birmingham	144	Industrial	6	Grassy area in industrial neighborhood	Industrial, older residential; foundry 50 ft across street, two others nearby; old house adjacent
Leeds	143	Industrial	6	Small town backyard with trees	Small town central business area within two blocks; major cement mill several blocks south
Tarrant City	130	Industrial	6	Open grassy area adjoining alley behind commercial strip	Industrial, commercial along highway; gravel quarry three blocks north; coke ovens, cupola to southwest
East Thomas	128	Industrial	6	Grassy plot adjoining highway	Heavy traffic immediately adjacent; residential generally; 2 to 3 miles up valley from major steel works
Bessemer	98	CBD; industrial	6	Near city center – grassy area adjoining railroad tracks and unpaved driveway	Center-city commercial and medium traffic; no nearby major sources, foundry within 1 mile
UAB	96	Major CBD	45	Rooftop office building near intersection	Dense CBD and heavy traffic; medical center complex with parking area adjoining
Downtown	94	Major CBD	10	Corner Post Office official parking lot	Dense CBD, heavy traffic; expressway four blocks NW, railroad tracks four blocks SE
Irondale	90	CBD	6	Grassy plot adjoining railroad tracks and fire station	Small town business center and residential; railroad yards to northeast
Fairfield	90	Industrial-residential	10	Side lawn of police/fire station	Nearby residential; major steel works six to ten blocks west through northwest
West End	88	Dense residential	6	Grassy island in street intersection	Older residential; minimal commercial at intersection; relatively light traffic
Woodlawn	84	Dense residential	6		Older residential; airport to northwest
Huffman	51	Open residential	6	Raised grassy area overlooking highway	Sparsely-built wooded residential; along major divided highway; shopping center half mile north
Mountain Brook	47	Open residential	6		Open, wooded residential

heights are produced by a specific hi-vol mounting arrangement, which is illustrated in Figure 14; though the hi-vols are readily accessible, the agency has not experienced any vandalism problems of concern. The 10-foot sites were originally mounted as in Figure 14; the 10-foot height resulted when they were subsequently put on top of gas-sampling trailers as the latter were installed.

This generally low height of sampling is quite unusual. Given the generally-observed decrease in TSP levels with height, it would be expected that the low heights would inaccurately portray Birmingham as having higher levels in comparison with other cities where sampling is more routinely at rooftop height. However, the magnitude of this effect in the Birmingham area is not clear; most of the sites seem, on visual inspection, to be relatively free of the very localized fugitive dust sources that are probably the major cause of the height effect.

The minor scheduling anomalies mentioned previously are the only negative aspects to what is otherwise an excellent, extensive, monitoring effort. And these are only negative in the sense that they require interpretations and accommodations on the part of the national data bank and other outside users. For instance, the hi-vol at the Leeds site is generally operated daily for the five working days each week, and not over the weekend; thus, to whatever extent the weekend levels are lower, the mean measured TSP levels will overestimate the long-term average exposure. Similarly, at some of the hi-vol stations normally operating on the every-sixth-day schedule, it is the practice to take additional, daily, samples during specific episode periods. This also can bias the average TSP level upward in comparison to a straight statistical sample. In both these cases, again, it should be emphasized that these interpretation difficulties pose no problem to the agency staff, but may possibly to the unwary outside user of the data.

Reproduced from
best available copy.

Figure 14. East Thomas hi-vol site, illustrating typical 6-foot high mounting

METEOROLOGY AND CLIMATOLOGY

Plots of annual rainfall and heating requirements over the period 1957 to 1974 are included in the appendix; they indicate that the years since 1970 have been slightly wetter and slightly warmer than the longer-term average. In certain circumstances, this might be expected to produce somewhat lower TSP levels; however, with the sizable change in industrial emissions over the years, it is not reasonable to expect any identifiable effect from trends in precipitation or temperature.

In order to investigate the possible effect of rainfall and other climatic factors it is more useful to consider the seasonal pattern throughout a single year, within which emission and regulatory factors are relatively constant. The appendix includes plots of the seasonal patterns of rainfall, in both days per month and inches of rain per month, and of wind speed. Figure 7 presented a seasonal pattern of TSP levels at the six episode sites, which is somewhat smoother than that for the entire network because the sites sample much more frequently. The most immediate features of the seasonal pattern are the low point at September and the peak in October. The plot of rainfall indicates that August and September were wetter than usual, and that October (as is typical) was very dry. Smaller-scale features of the patterns don't match so well, however. In addition, such a comparison ignores wind speed, which does vary dramatically through the year. Overall, it appears necessary to utilize a more extensive analysis in order to define precisely the degree to which meteorological parameters are responsible for the seasonal variation in TSP levels. Initial efforts, however, have failed to provide a straightforward conclusion, due largely to the difficulty in representing a clear-cut model for the effect of precipitation.

The influence of meteorology is most pronouced at the level of day-to-day variations. Consideration of the daily hi-vol data from the episode sites makes possible some dramatic examples of the effect short-term weather changes can have on TSP levels. The following examples show, first, the effect of rainfall in reducing levels and, second, the effect of poor dispersion in elevating them.

February 12 - 16, 1974 - The samples removed the morning of February 12, after a Monday afternoon and Tuesday morning with generally light northerly winds, were high; Downtown, Fairfield, and Bessemer averaged 194 $\mu g/m^3$. The following morning, after a shift to southerly winds with a significant increase in speed, the same sites averaged 113 $\mu g/m^3$. Then during the afternoon and evening of Wednesday the 14th, it rained - 1.10 inches until it stopped at midnight. The samples the following morning averaged 81 $\mu g/m^3$. Rain began again the afternoon of the 15th, and continued through the night, with another 0.80 inch by morning; the samples during the 20-odd hours of rain averaged 62 $\mu g/m^3$, and only 35 $\mu g/m^3$ at the Downtown and Bessemer sites. Following the rain, which ended during the morning of the 16th, levels at the three sites averaged 95 and 125 $\mu g/m^3$ on the next 2 days. Significantly, this pattern is less obvious at the more industrial sites than it is at the center-city sites, which give a more integrated picture; at all sites, however, the effect of rainfall is apparent.

October 1974 - The best illustrations of the massive impact from adverse dispersion conditions are seen in the data already presented in Figures 9 and 10. The major high levels on September 19 and October 11, 18, and 25 are all attributable to high-pressure systems with relatively slow movement; although none was so severe as to be properly termed a major stagnation, each was accompanied by essentially total calms overnight and only very light winds during the day. These meteorological conditions are fairly common in the southern Appalachian region in the fall, and are easily capable of doubling or tripling normal TSP levels.

REGULATIONS

The Jefferson County Board of Health adopted air pollution control regulations in January 1972, pursuant to the Alabama Air Pollution Control Act of 1971. The regulations have chapters on general provisions, permits, variances and air pollution emergencies. Also, included are regulations for sulfur compound emissions, hydrocarbons, carbon monoxide, nitrogen oxides, motor vehicle emissions and control of complex sources. The chapters relating to Open Burning and Incineration and the Control of Particulate Emissions are summarized below.

Open Burning

Open burning is generally banned, with exceptions for certain small fires, e.g., cooking and recreational, and fires for special purposes, e.g., fire abatement, pest control, agriculture. Land clearing and agriculture probably account for the majority of open burning operations.

Incineration

Emissions from incinerators with capacity less than 50 tons per day are limited to 0.20 pounds per 100 pounds of refuse charged. Larger incinerators (greater than 50 tons per day) are restricted to 0.10 pounds of particulate matter per 100 pounds of refuse charged. The regulations further require that all incinerators be operated in such a way as to prevent odors.

Emissions from incineration of wood, peanut, and cotton ginning wastes cannot exceed 0.40 pounds per 100 pounds of material charged. The incinerators should be designed, equipped and maintained for maximum burning capacity.

Visible Emissions

No emissions can be darker than Ringlemann Number 1 or 20 percent opacity. Contaminants may be emitted not darker than No. 3 on the Ringlemann Chart or 60 percent opacity for periods aggregating less than 3 minutes in any 60 minutes.

Fuel Burning Equipment

Emissions from fuel combustion equipment are limited in accordance with a specific curve of emissions as a function of energy input. This curve is presented in Figure 15, along with a general background of similar regulations from other jurisdictions. The gray shaded area in the figure indicates the area in which the vast bulk of the regulations lie; the upper and lower dashed lines represent the extremes of such regulations. The Jefferson County curve is generally within the typical range, but is among the more lenient for small units, with a limit of 0.6 pounds per million Btu for units under 10 million Btu per hour.

Industrial Process Regulations

The general process weight curve is illustrated in Figure 16 in a manner similar to that in Figure 15. This regulation, which is clearly typical of such curves, applies to most industrial processes; small foundry cupolas, cotton gins, kraft pulp mills, and wood waste burners are governed by slightly different figures, while coke ovens are regulated by a different type of regulation.

Coke Ovens

Recognizing that emissions from coke ovens are hard to measure or estimate, as well as being hard to control, the coke oven regulation (Section 6.9) instead prescribes specific maintenance and refurbishing

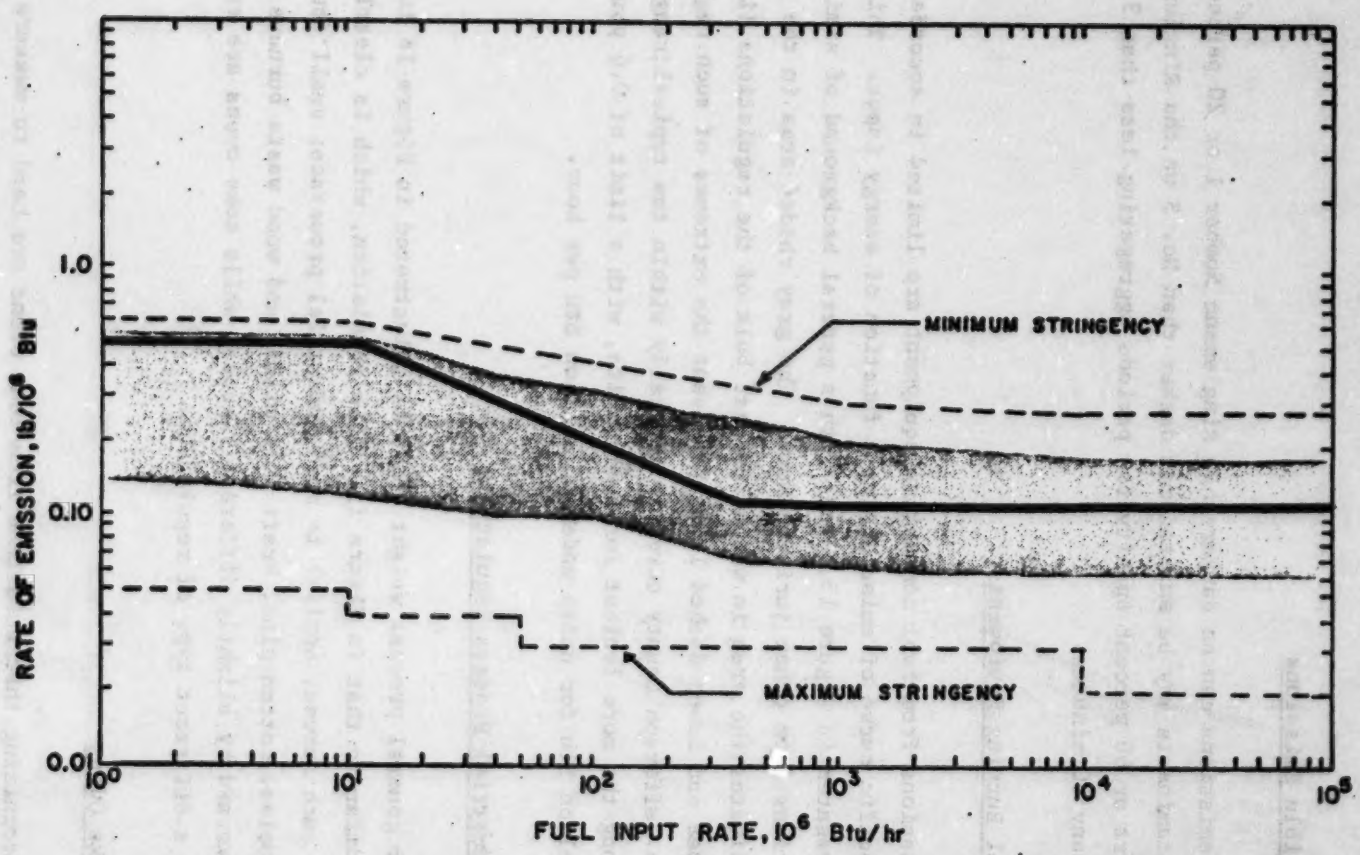

Figure 15. Emissions limitations for fuel combustion operations

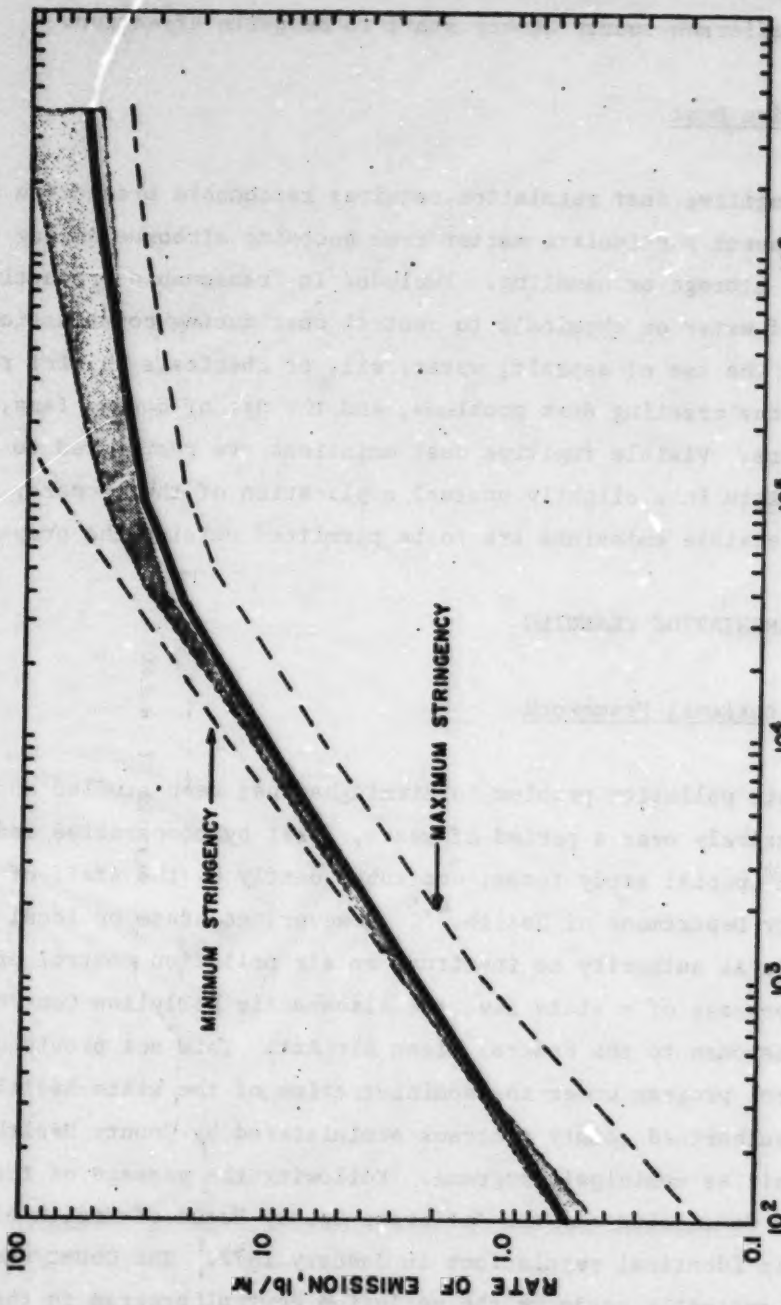

Figure 16. General process weight regulations

requirements. This regulation is included as Table 7; it is believed by the Jefferson County agency staff to be quite effective.

Fugitive Dust

The fugitive dust regulation requires reasonable precaution to be taken to prevent particulate matter from becoming airborne during transportation, storage or handling. Included in "reasonable precautions" are the use of water or chemicals to control dust during construction or demolition, the use of asphalt, water, oil, or chemicals on dirt roads or other surfaces creating dust problems, and the use of hoods, fans, and fabric filters. Visible fugitive dust emissions are restricted to the property of origin in a slightly unusual application of the property line concept – no visible emissions are to be permitted outside the property lines.

IMPLEMENTATION PLANNING

Institutional Framework

The air pollution problem in Birmingham has been studied and monitored extensively over a period of years, first by cooperative federal-state-local special study teams, and subsequently by the staff of Jefferson County Department of Health.[4,5] However, no state or local authority had any legal authority to institute an air pollution control program until the passage of a state law, the Alabama Air Pollution Control Act of 1971, in response to the Federal Clean Air Act. This act provided for a state control program under the administration of the state health department, and authorized county programs administered by County Health Departments, as well as municipal programs. Following the passage of the Act, the State Commission and the Jefferson County Board of Health adopted essentially identical regulations in January 1972. The County Health Department currently conducts the pollution control program in the county and all municipalities, with communication and reporting to the state and federal programs as consistent with the State Act and the Federal Clean Air Act of 1970.

Table 7. JEFFERSON COUNTY COKE OVEN REGULATION

6.9 Coke Ovens.

6.9.1 Applicability. The provisions of this Part (except 6.9.10) shall apply to the production of coke in existing conventional slot-oven coke batteries.

6.9.2 Unloading and Transfer of Coal and Coke. Every person operating coke ovens shall apply all reasonable measures to prevent emissions from coal unloading, transfer, and coke transfer.

6.9.3 Charging. There shall be no visible emissions during the charging cycle from the charging holes or the larry car of any battery with an opacity which is greater than twenty percent (20%) (equivalent to Ringlemann No. 1) except for an average period or periods not to exceed three (3) minutes of any consecutive sixty (60) minutes on batteries with less than seventy (70) ovens nor more than four (4) minutes of any consecutive sixty (60) minutes on batteries with seventy (70) ovens or more.

6.9.4 Pushing. There shall be not visible emissions during the pushing cycle, other than water mist or vapor, with an opacity which is greater than forty percent (40%) (equivalent to Ringlemann No. 2) for more than one (1) push per hour per battery or for more than two (2) consecutive pushes from the same oven.

6.9.5 Topside Emissions.

(a) Any leak discovered on the topside of a battery shall be wet sealed or the oven shall not be recharged until the necessary repairs are made.

(b) At no time shall there be leaks in more than ten percent (10%) of the offtake piping and no more than five percent (5%) of the charging hole lids on any one battery.

6.9.6 Coke Oven Doors.

(a) There shall be no visible emissions, except non-smoking flame, from any opening on the coke oven doors from more than fifteen percent (15%) of the coke oven doors on any battery at any time.

(b) If a self-sealing door fails to seal during the coking cycle, it shall be adjusted, repaired or replaced prior to a subsequent charge of that oven.

Table 7 (continued). JEFFERSON COUNTY COKE OVEN REGULATION

(c) Luted doors which fail to seal after the oven is charged shall be reluted promptly.

(d) Every person operating coke ovens shall have a facility to maintain and repair coke oven doors, and shall maintain an inventory of one (1) coke oven door per twelve (12) ovens operated.

6.9.7 Oven Maintenance.

(a) All ovens shall be maintained in good condition to promote complete coking of coal.

(b) All coke oven cracks are to be sealed as soon as practicable after they are detected.

(c) As directed by the Health Officer, reasonable records of the maintenance of oven doors, oven burners, and oven interiors are to be made and retained for a reasonable time.

6.9.8 Combustion Stacks. There shall be no visible emissions, other than water mist or vapor, of a shade or density darker than that designated as No. 1 on the Ringlemann Chart or 20% opacity from any stack except for a period or periods aggregating not more than three (3) minutes in any consecutive sixty (60) minutes.

6.9.9 Quenching.

(a) No person shall operate a coke oven plant without baffles installed and properly operating in the quench towers.

(b) Water introduced to the quenching station must be of a quality approved by the Health Officer.

6.9.10 Notwithstanding the specific limits set forth in this Part, in order to maintain the lowest possible emissions of air contaminants, the highest and best practicable treatment and control for particulate matter currently available shall be provided for any new coke producing facilities.

Implementation Planning Methodology

The Implementation Plan for the State of Alabama was adopted by the Alabama Air Pollution Control Commission on January 18, 1972, and submitted by Governor Wallace on January 25, 1972; supplemental information was submitted on several occasions through October 1973. The portions of the plan relating to the control of particulate emissions, including those in Birmingham and Jefferson County, were approved; they proposed meeting both the primary and secondary national standards by July 1975, through the implementation of the control regulations described previously.

Air Quality Data Base – The ambient monitoring data for particulates that was available at the time of SIP development was adequate to permit county-by-county projection of the impact of plan implementation. In the case of Jefferson County, annual geometric means from four sites were presented with the 237 $\mu g/m^3$ mean at the North Birmingham site being the highest, in the AQCR as well as the county.

Emissions Data Base – The emissions inventory used for plan development statewide was prepared for that purpose; the summary of emissions for Jefferson County (Table 8) is essentially similar to the emissions utilized by the local program, and are considered as accurate as such data typically are. The effect of the control strategy; i.e., the implementation of the regulations, was calculated on a source-by-source basis, using as 1975 emissions from each point source either the permitted emissions under the regulations, or the 1971 value if emissions were already below the maximum permitted. Growth in emissions was not included in the projected 1975 estimates, but rather was considered subsequently. Similarly, no change in area source emissions was projected.

Estimation/Projection Methodology – The calculations demonstrating the attainment of the standard were made using a straightforward linear rollback model, applied on a county-by-county basis, utilizing a background level

of 35 $\mu g/m^3$. As applied to the 237 $\mu g/m^3$ maximum value in Jefferson County, the procedure provided the following comparison between the reduction required and that achieved:

Percent Reduction Calculations

Maximum Concentration = 237 $\mu g/m^3$

Background Concentration = 35 $\mu g/m^3$

Secondary National Standard = 60 $\mu g/m^3$

Percent Reduction Required = $\left(\frac{237 - 60}{237 - 35}\right)100 = 87.6$ percent

Existing Emissions (1971) = 161,806 tons/year

Future Emissions (1975) = 14,954 tons/year

1975 Percent Reduction Achieved = $\left(1 - \frac{14,954}{161,806}\right)100 = 90.8$ percent

Allowable Controlled Emission Growth = 90.8 percent - 87.6 percent
= 3.2 percent

Table 8. JEFFERSON COUNTY EMISSIONS FROM SIP (TONS PER YEAR)

Source category	Existing (1971)	Under strategy (1975)	% Reduction
Fuel combustion	12,314	850	93
Industrial process	138,983	3,619	97
Solid waste	24	0	100
Area sources	10,485	10,485	0
	161,806	14,954	91

Thus the 1971 SIP projects meeting the secondary standard with a few percent to spare, primarily through the massive reduction of point source fuel use and industrial process emissions. Any reduction in area source emissions would permit an increase in the future growth permitted within the standards. The 3.2 percent margin in Jefferson County was the smallest in the state, so in this sense it can be said that Birmingham air quality was the controlling factor in the state plan development

FACTORS INFLUENCING TSP LEVELS

By way of summarizing, this Section considers the various hi-vol sites and attempts to draw such conclusions as are possible concerning the dominant factors influencing each site. As a vehicle for doing this, particulate levels at each site were sorted by wind direction into 36 averages — an analysis commonly known as a pollutant rose, although they are presented here in a linear format. Using wind data from the Birmingham Municipal Airport (Figure 4), these analyses should be fairly precise at least for sites within the central valley, although wind direction data is always somewhat unreliable at low wind speeds.

To begin with the site at Leeds, it appears from all evidence that the major influence is simply the local cement plant. The pollutant rose in Figure 17 shows a clear peak to the SSW, the direction of the cement plant, and neither the emission inventory nor the site visit suggest any other source of significance. The reasonably high levels at the lowest points in Figure 17 are a reminder, first, of the fact that there is a great deal of smoothing involved in distributing an integrated 24-hour hi-vol value by 3-hour wind observations and second, of the fact that the Leeds site does not operate on weekends, when some portions of the cement plant are shut down.

Another interesting feature in Figure 17 is the peak in the pollutant rose at wind directions of 30 to 50 degrees; there is no apparent local source in this direction at Leeds. Furthermore, there is an indication of a similar peak, to one degree or another in every pollutant rose tabulated in Birmingham, even at those sites where there is no clear influence from any source in that direction. The peak is apparent at the West End site (Figure 18) and even at the Huffman site (Figure 19), the farthest to the northeast. This coincidence of peaks at many dissimilar sites suggests an effect of some large, synophic-scale phenomenon, or some type of seasonal wind direction anomaly, but an immediate explanation is not evident.

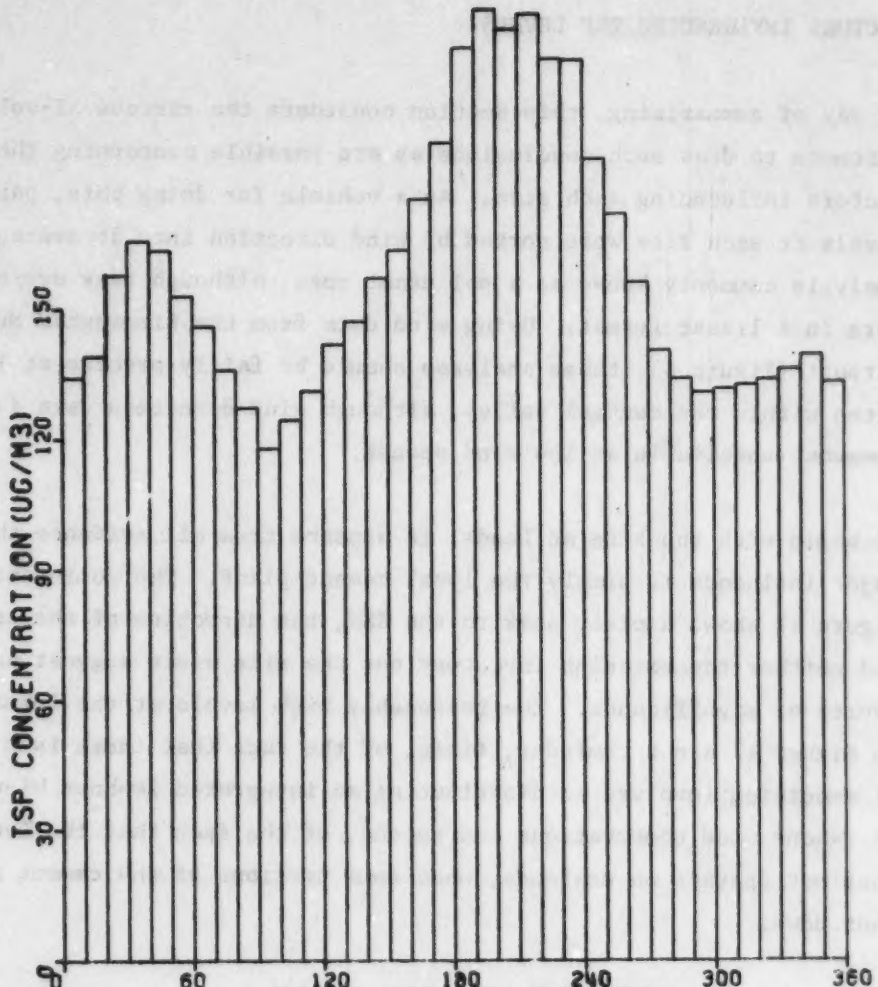

Figure 17. TSP versus wind direction at Leeds site

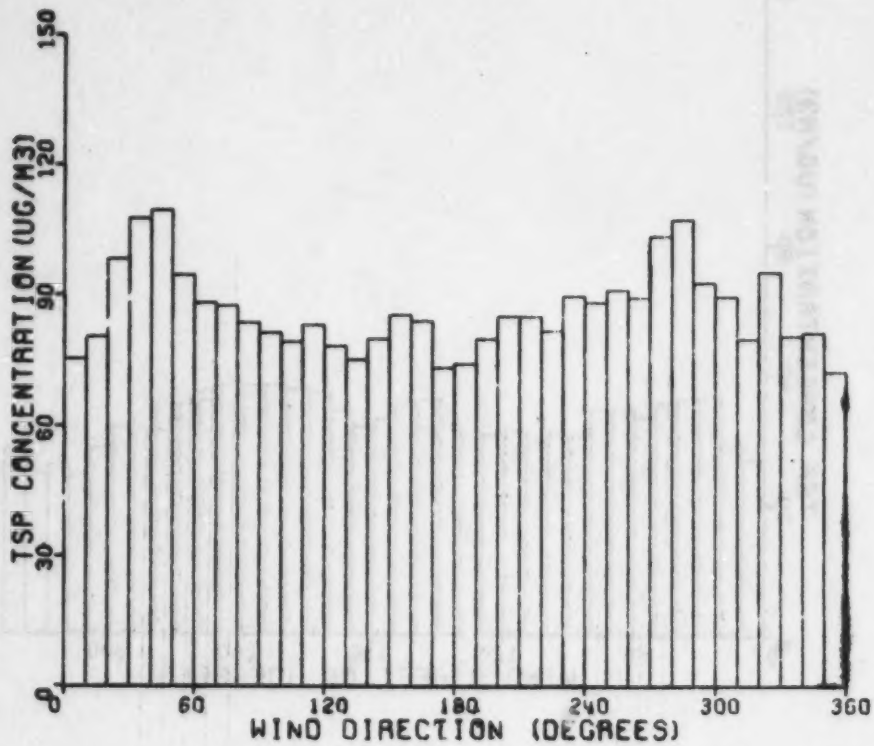

Figure 18. TSP versus wind direction at West End site

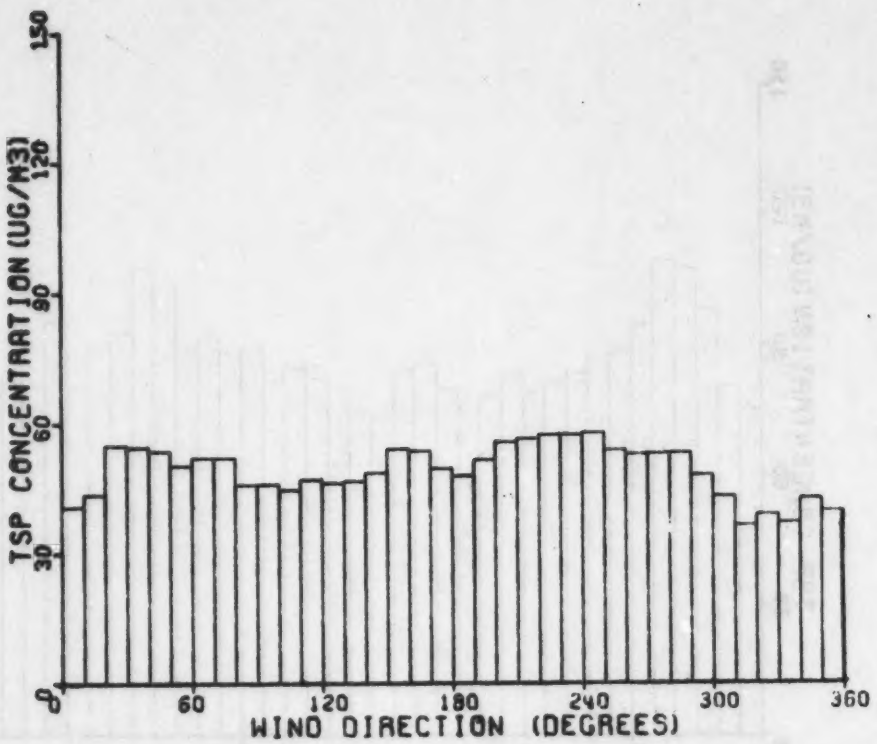

Figure 19. TSP versus wind direction at Huffman site

In general, the pollutant roses at most of the other Birmingham sites (Figures 20 through 25) indicate peaks in the direction of the nearest major industrial concentrations. The Bessemer site reflects the fairly uniform distribution expected of a center-city site. The Fairfield site reflects the major open hearth works to the west, as does the East Thomas site. The North Birmingham site reflects the foundry across the street to the northeast, another to the SSW, and generally high levels overall. The Tarrant City site, literally surrounded by major sources, seems the most erratic, but much of this is caused by a less frequent sampling schedule. The downtown site, perhaps the best integrated indicator of air quality, shows high levels with winds from about 220 degrees around to 60 degrees, likely relating to the entire industrial area lying along the northwestern edge of the city.

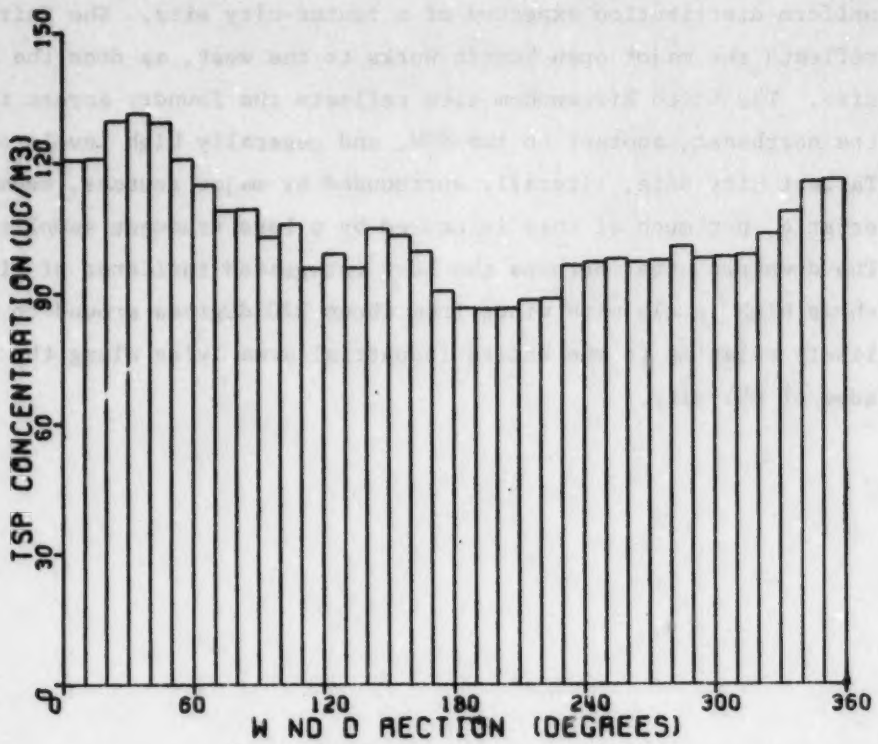

Figure 20. TSP versus wind direction at Bessemer site

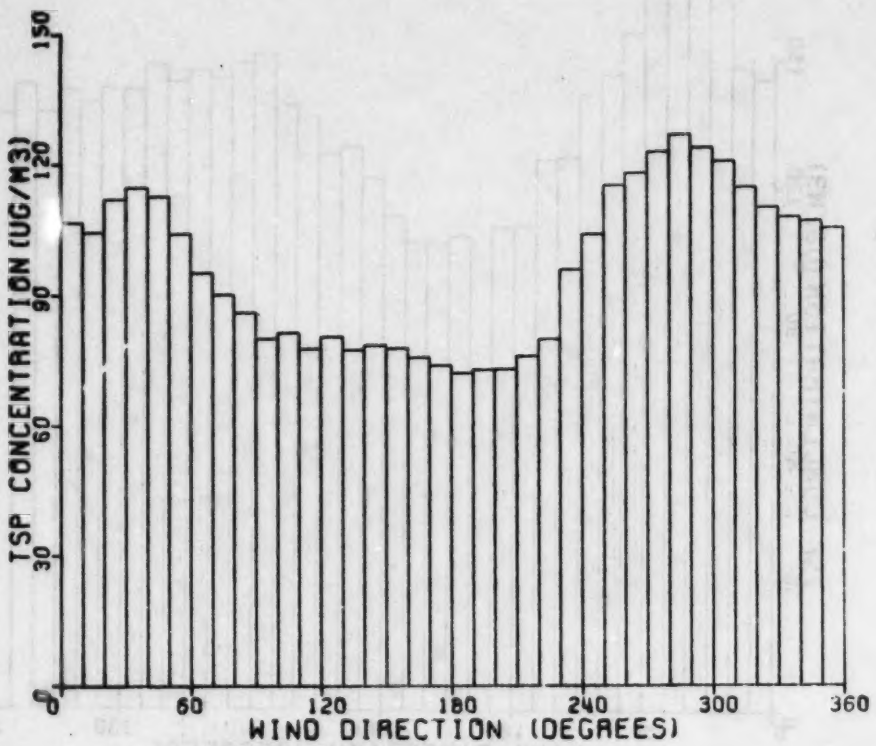

Figure 21. TSP versus wind direction at Fairfield site

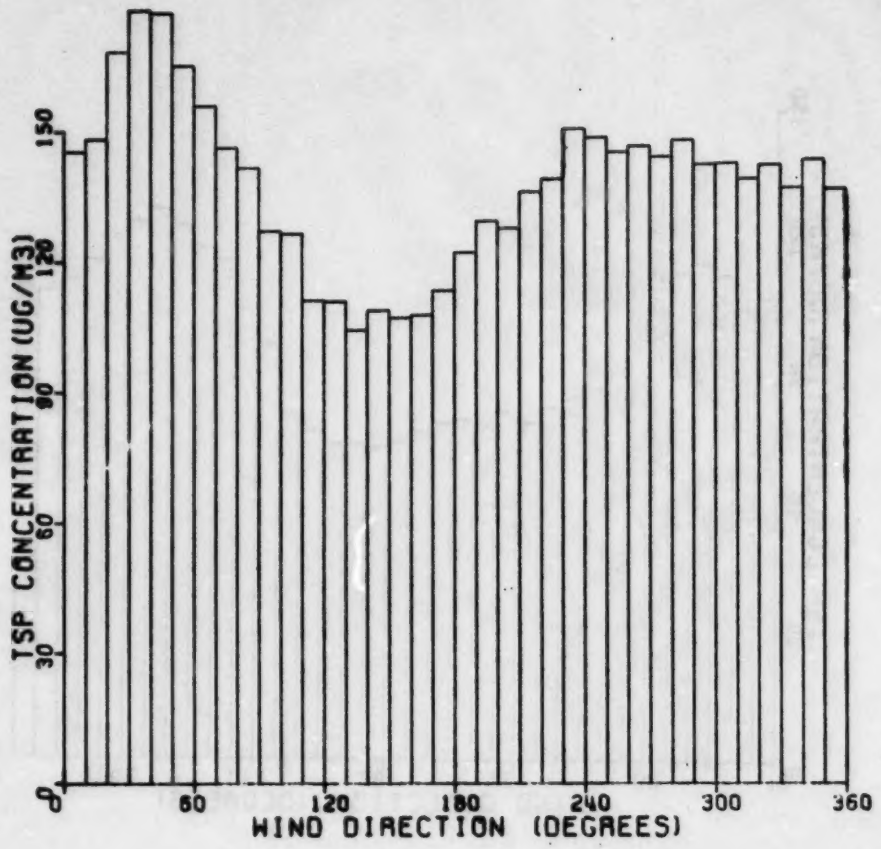

Figure 22. TSP versus wind direction at East Thomas site

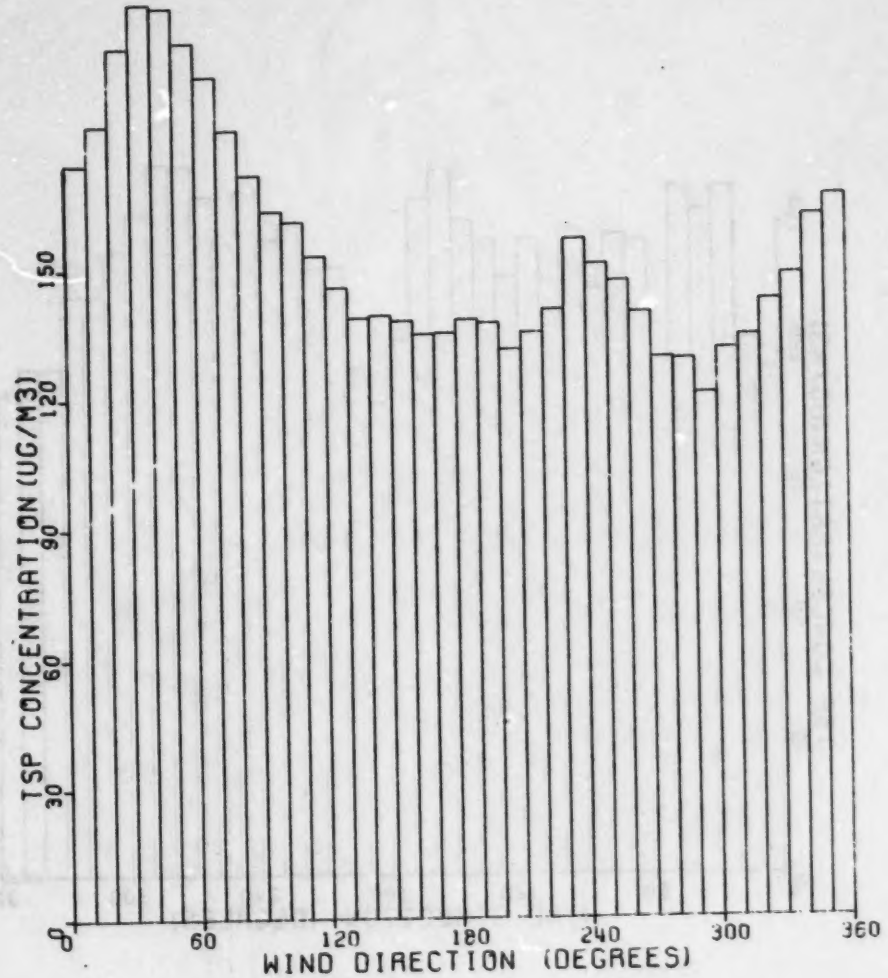

Figure 23. TSP versus wind direction at North Birmingham site

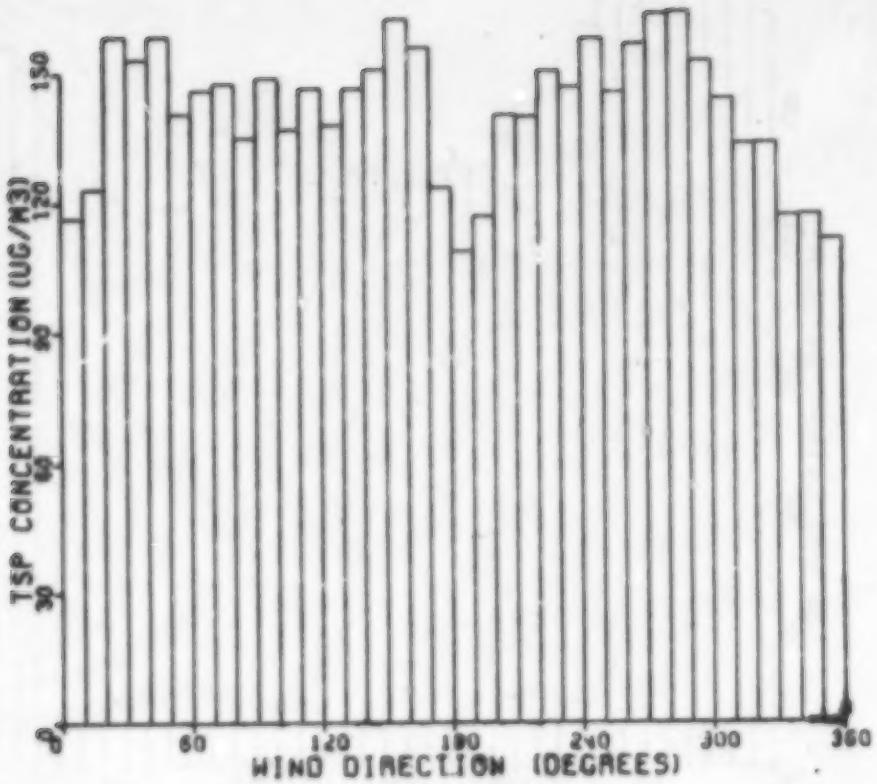

Figure 24. TSP versus wind direction at Tarrant City site

Figure 25. TSP versus wind direction at downtown site

SECTION III

SUMMARY AND CONCLUSIONS

SUMMARY

Air Quality

Eleven of the 13 hi-vol sites in the county exceed the annual standard frequently, with levels ranging from 84 to 144 $\mu g/m^3$, and three of the sites exceed the 24-hour standard very frequently. However, levels have been declining significantly since the mid-1960's, and especially since the early 1970's since the advent of the control program. Decreases of about 50 percent have occurred at the industrial/residential sites that still have the highest levels.

Emissions

Particulate emissions in Jefferson County are estimated at over 200,000 tons per year. Nearly 90 percent of this total is from industrial processes, with the remainder mostly from fuel combustion. The fuel consumption contribution is low because of the moderate climate and the extensive use of natural gas, and because the electric generating capacity is located outside the county.

The industrial emissions are primarily from the steel industry, especially open hearths, coke ovens, and foundries, and from Portland cement plants. Emissions from each of these categories have been declining significantly — the open hearths through economic replacement, the others because of regulatory controls.

Meteorology and Climatology

The Birmingham area suffers from quite adverse dispersion conditions. It is located in the area of the eastern United States where stagnant high pressure systems are the most frequent, and in addition the valley topography increases the frequency and severity of nocturnal radiation inversions. Precipitation is moderately heavy (53 inches per year) and plays a major role in determining day-to-day variations in TSP levels.

Regulations and Compliance

The Jefferson County Health Department has enforced pollution control regulations since the passage of state enabling legislation in Alabama in 1971. The general process weight regulation, and specific regulations for foundries and cotton gins, are on the more stringent side of the range of regulations studied. Coke ovens are controlled with a regulation establishing standards of maintenance and good practice. The fuel combustion regulation is generally typical of those surveyed, though less stringent in the case of small units. As used in Jefferson County currently, it has the effect of converting most sources to gas, so it is unlikely that a tightening of the emission limitations would have any significant effect. About half the major point sources are in compliance, with the balance on compliance schedules running through May 1976 at the latest.

Monitoring Network Design

The hi-vol monitoring network is adequately representative of the various areas of Birmingham and environs, and involves extensive extra monitoring for episode surveillance purposes. The network includes a large proportion of sites in areas between industrial and residential neighborhoods, which tends to overemphasize the degree to which Birmingham violates the national standards in comparison with other cities. A unique circumstance of the network is the generally low heights at which the hi-vols are

operated (most at 6 feet); this also tends to lead to artificially high measured TSP levels in comparison with many other cities.

SIP Planning

The SIP was developed using a rollback model with adequate air quality and emissions data. The site providing the highest value is highly industrial in nature, so that the rollback of major industrial emissions would appear to be as accurate and appropriate as such can be.

FACTORS INFLUENCING AIR QUALITY

The principal factor in Birmingham's general failure to meet the standard is simply the massive industrial emissions total, coupled with the relatively few years of actual control efforts. Adverse meteorology conditions make meeting the standards more difficult, and in particular cause extreme short-term peak levels. In addition, the aggregate assessment of the county's compliance is affected by a high proportion of industrial sites, and the generally low height of sampler operations, both of which tend to indicate levels higher than otherwise.

In aggregate assessment, it is apparent that the major reason why sites in Birmingham are not meeting the national standard is simply that such a great magnitude of industrial emissions has not been able to be totally reduced in a 3-year period. In a strict sense, this could perhaps be termed a failure, but in any realistic sense it must be recognized that more has been done in Birmingham in the face of a major problem than in many areas faced with smaller difficulties.

REFERENCES

1. Holzworth, G. C. Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States. Office of Air Programs. Publication No. AP-101. Environmental Protection Agency. January 1972.

2. Emissions Inventory of Agricultural Tilling, Unpaved Roads, and Airstrips, and Construction Sites. Publication No. EPA-450/3-74-085. Environmental Protection Agency. November 1974.

3. Keagy, D. M. and J. J. Schueneman. Air Pollution in the Birmingham, Alabama Area. Technical Report A58-8. R. A. Taft Sanitary Engineering Center. 1958.

4. Hockheiser, Seymour, Sanford Horstman, and Guy M. Tate. A Pilot Study of Air Pollution in Birmingham, Alabama. Robert A. Taft Sanitary Engineering Center. Cincinnati, Ohio. May 1962.

5. Robison, Charles, J. Carroll Chambers, and Joseph Bates. Defining the Problem of Air Pollution in Meteopolitan Birmingham, Alabama. Jefferson County Department of Health. June 1967.

APPENDIX A

SUPPLEMENTARY INFORMATION

Table A-1. SAMPLING SITE REFERENCE DATA

SAROAD site code	Location	Address	UTM coordinates
01-0380-012	Downtown Birmingham	415 – 24th Street North	5184-37088
01-0380-005	North Birmingham	2817 – 30th Avenue North	5172-37124
01-1300-003	Fairfield	5229 Court B	5079-37049
01-2140-003	Leeds	122 – 8th Street N.E.	5425-37115
01-0380-019	East Thomas	817 – 21st Avenue West	5140-37091
01-3200-001	Tarrant	1818 Pinson Street	5215-37159
01-0340-001	Bessemer	18th Street – 1st Avenue	5044-36955
01-0380-010	Woodlawn	2nd Avenue – 52nd Street North	5223-37107
01-0380-011	West End	14th Street – Pearson Avenue	5136-37055
01-1880-002	Irondale	101 – 20th Street South	5272-37108
01-0380-003	NASN	720 – 20th Street South	5186-37070
01-0570-001	Huffman	942 Huffman Road	5287-37179
01-2540-001	Mountain Brook	3016 Overton Road	5241-37030

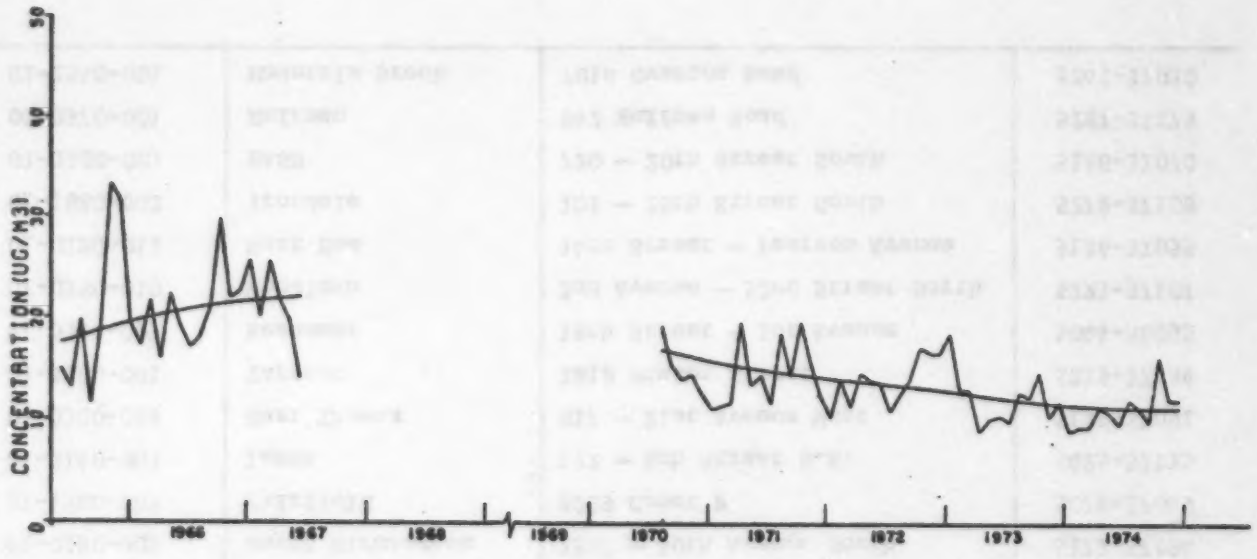

Figure A-1. Trend in TSP levels at Bessemer site

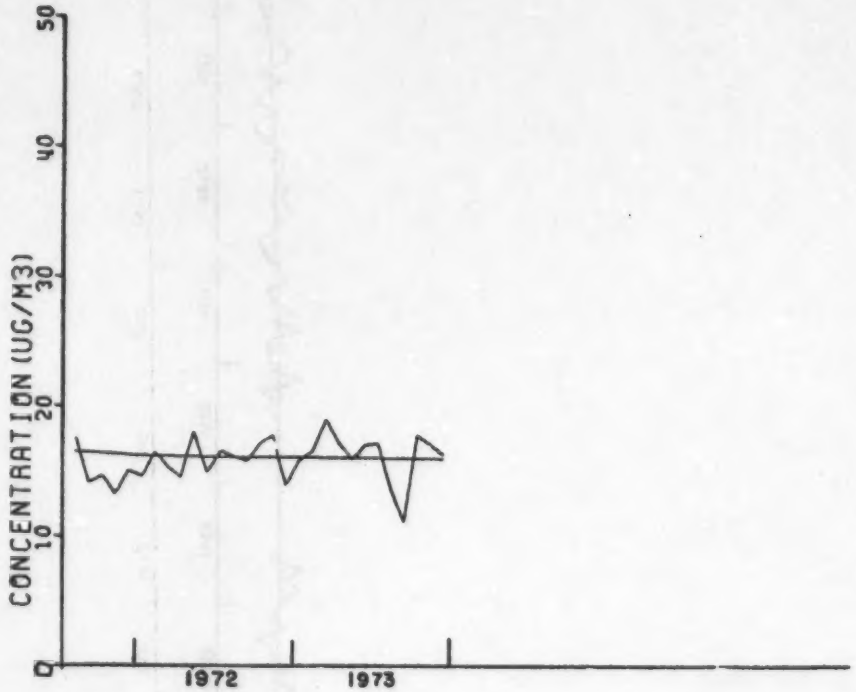

Figure A-2. Trend in TSP levels at Leeds site

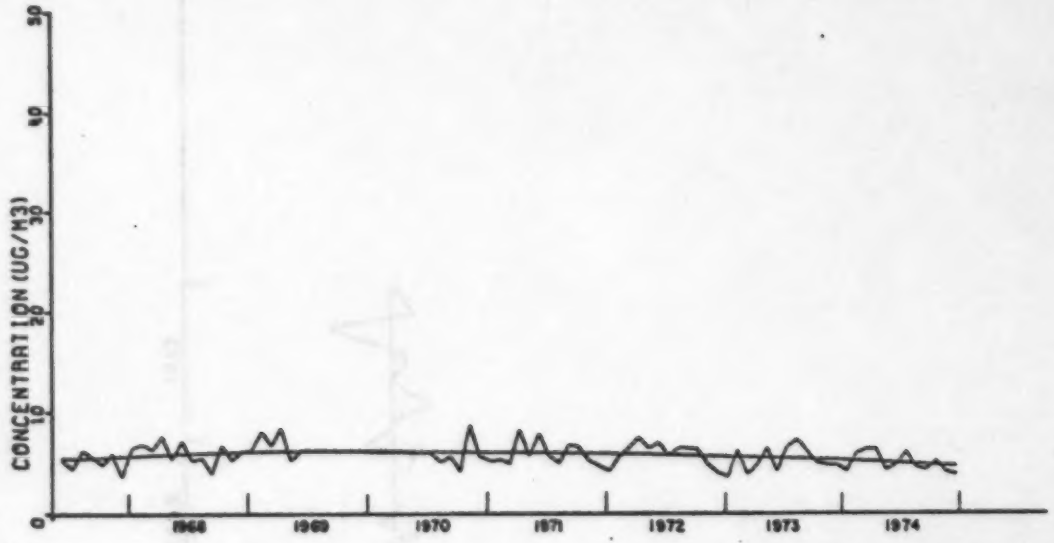

Figure A-3. Trend in TSP levels at Mt. Brook site

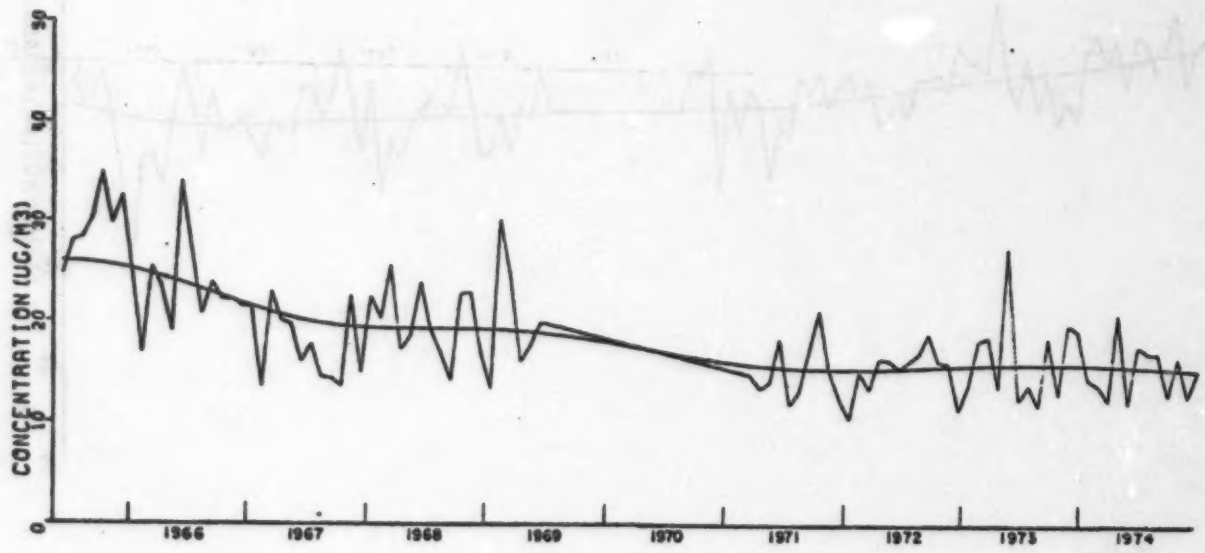

Figure A-4. Trend in TSP levels at Tarrant City site

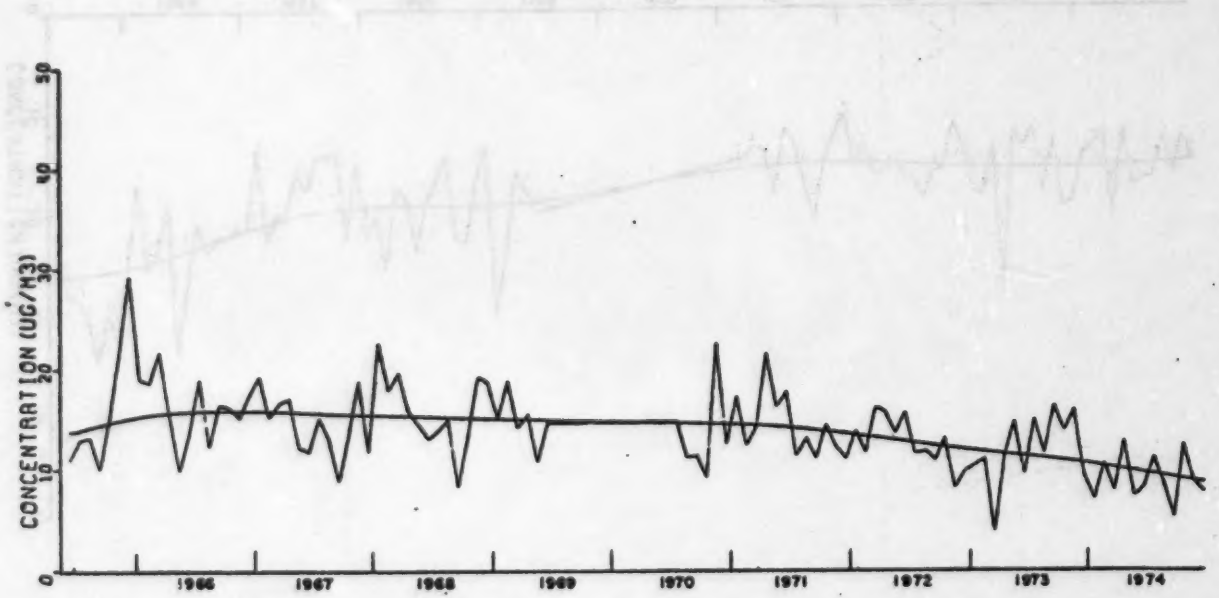

Figure A-5. Trend in TSP levels at Woodlawn site

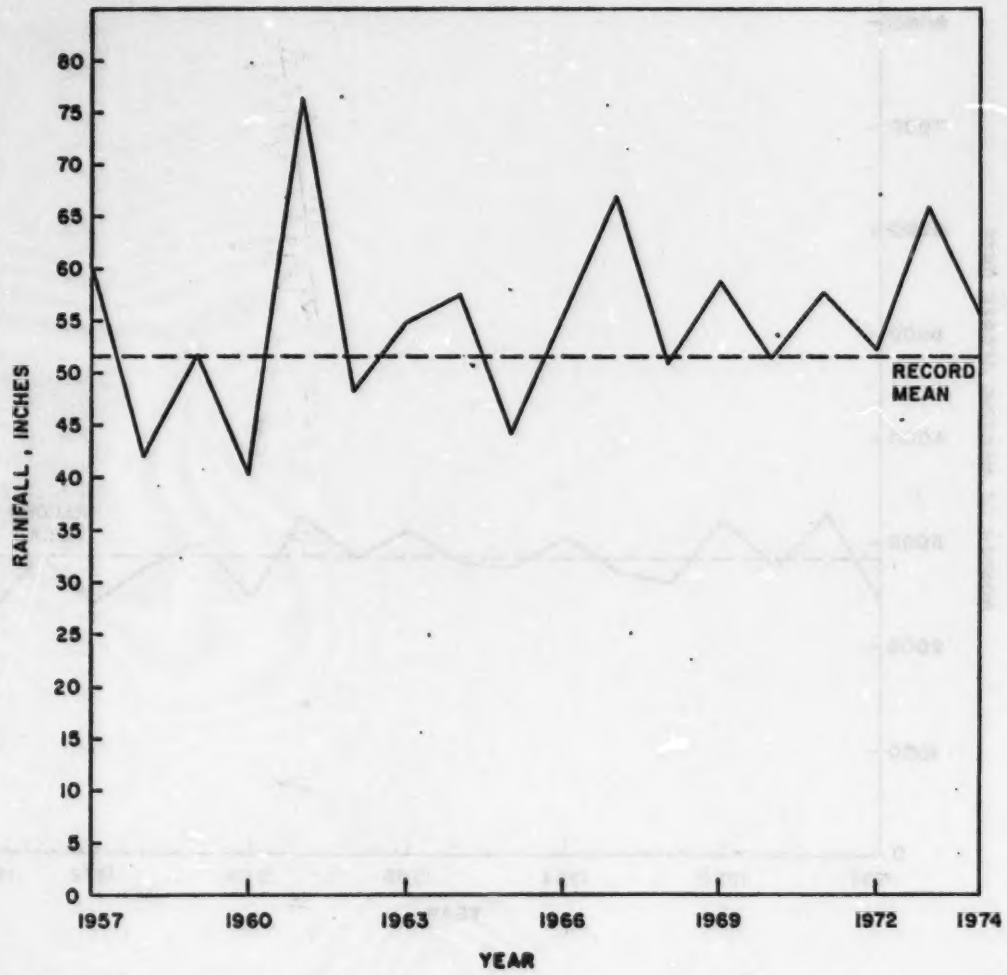

Figure A-6. Historical trend in annual rainfall

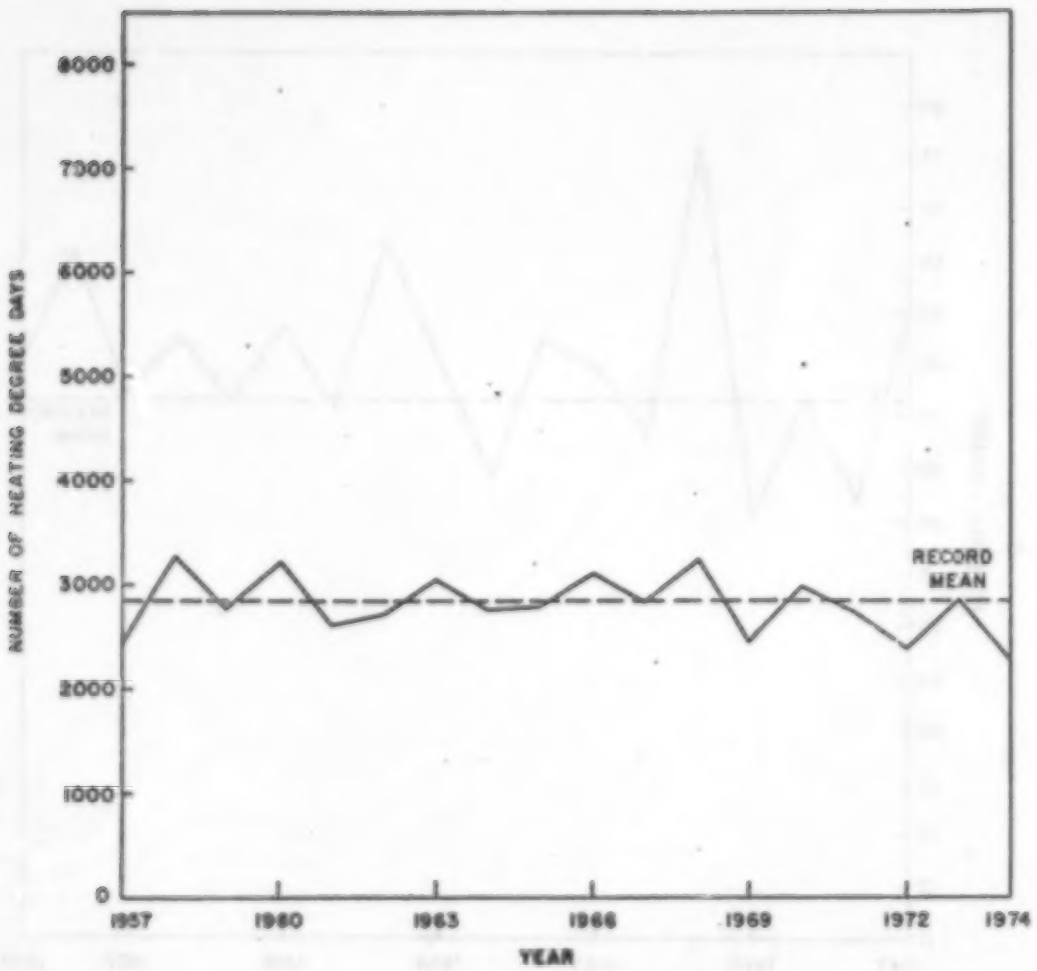

Figure A-7. Historical trend in annual heating demand

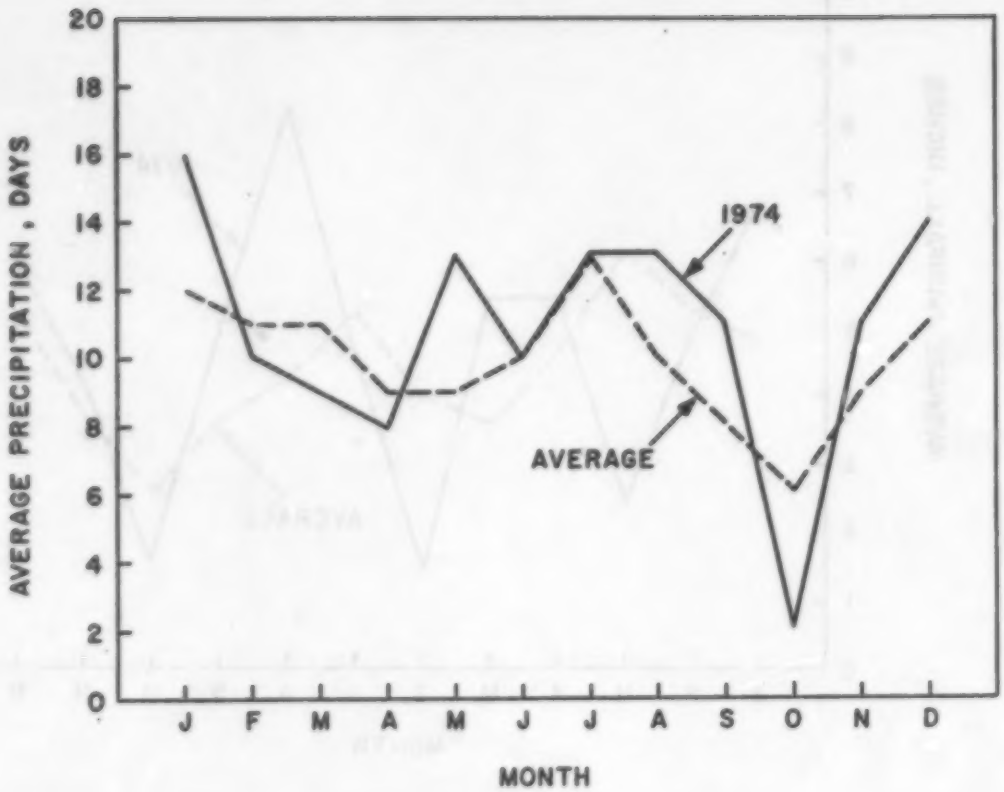

Figure A-8. Seasonal pattern of days with precipitation

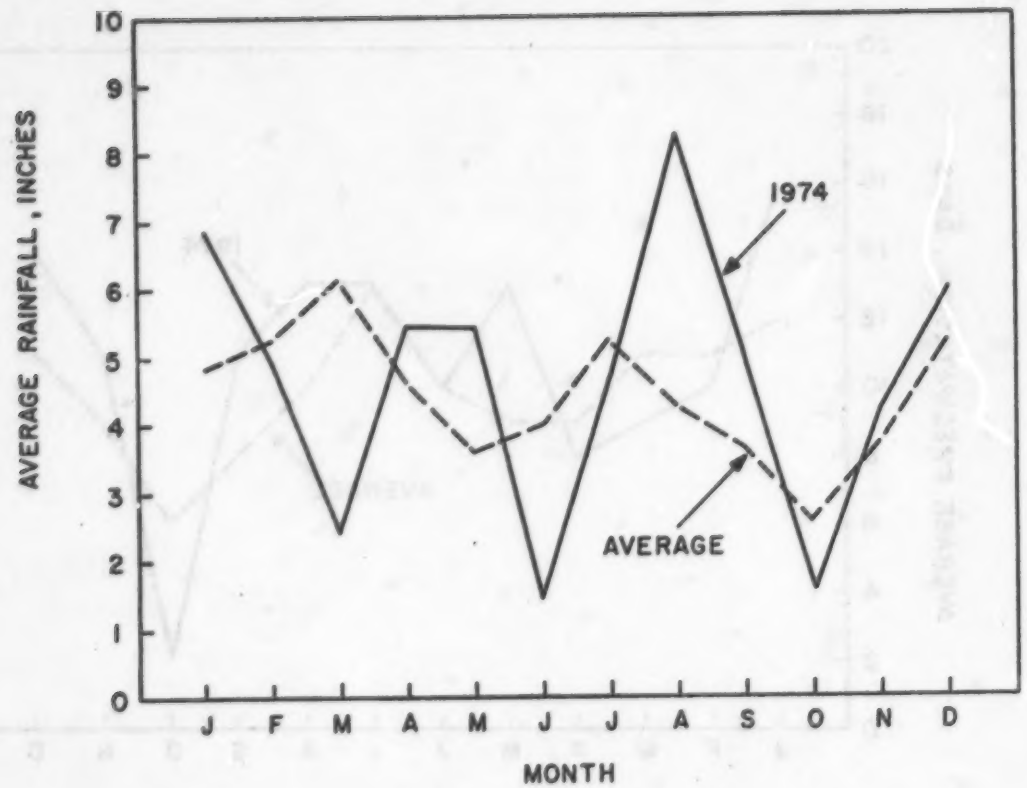

Figure A-9. Seasonal pattern of precipitation in inches

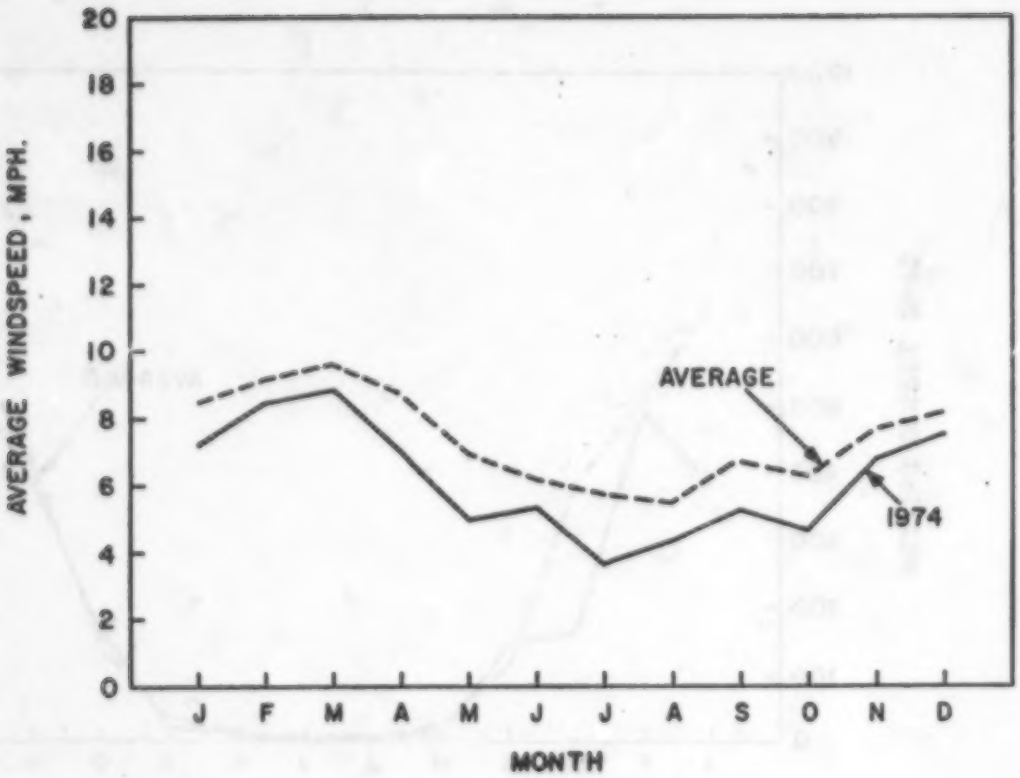

Figure A-10. Seasonal pattern in average wind speed

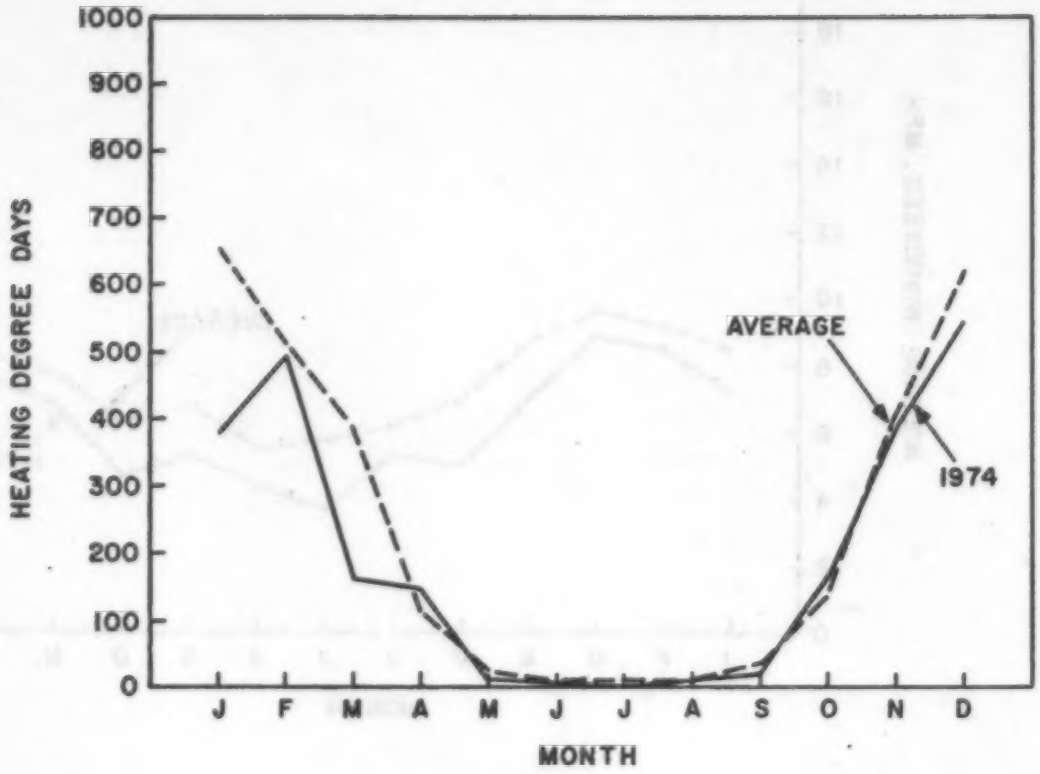

Figure A-11. Seasonal pattern in heating demand

APPENDIX B

PARTICLE CHARACTERIZATION

For most of the study cities members of the GCA study team acquired hi-vol filters from the 1974 filter banks of the cognizant local agencies. In addition, several filter samples for 1974 and selected earlier years were obtained from state and federal filter banks. Although some filters underwent chemical and/or detailed physical analysis, the principal purpose of obtaining filters was to utilize optical microscopy to identify each of the constituents that comprised more than five percent of the particulate mass. The selected filters, which were representative of several different site types and TSP levels within each study area, were returned to a clean room at GCA/Technology Division and carefully inspected for artifacts and evidence of sampler or filter malfunctions.

Each filter was then assigned a randomly generated five digit number which served as the only identifier for the filter sample so that each analyst had no information concerning the city, site, TSP loading or probable local sources associated with the sample. Furhtermore, the use of two laboratories for the microscopy, coupled with the randomly generated identifying numbers, permitted a fairly comprehensive quality control program in the form of blind replicate analyses. Since both laboratories utilized more than one analyst, these procedures resulted in as many as four microscopists observing samples from the same filter and, in some cases, the same analyst examining replicate samples from the same filter as many as three times.

The results of this quality control effort, which are presented in Volumes I and II, warn against relying very heavily on the results of any one filter analysis. However, the random match-up between analyst and filter sample should minimize systematic bias in composited results.

Forty-five filters from six sites were selected for analysis in Birmingham and Table B-1 summarizes the meteorological data for the selected sampling days. To gain some insight into the contribution of secondary particulates, much of which is too small to be observed by the microscopists, the annual average sulfate and nitrate concentrations for the NASN site are shown in Table B-2. The results for each of the filters submitted for routine analysis from all sites except the NASN site are presented in Table B-3. The results for each site have been averaged to give a composite of the particulate composition as shown in Table B-4. Seven filters underwent replicate analyses and the results of this task are presented in Table B-5.

Birmingham was one of three study cities selected for particulate trends analysis. To accomplish this task, four to six filters for each calendar year between 1970 and 1974 from the NASN sampling site were selected for microscopic analysis. The results of each filter analysis are presented in Table B-6 and a composite summary for each year is presented in Table B-7. It is difficult to discern any consistent trend in the composition of the particulate matter although there are variations year to year. The contribution of biological material was high in 1971 but that is primarily due to one observation day (April 11, 1971) which had an inordinate amount of pollen. Similarly, the higher average rubber content for 1970 was due to one observation day (January 2, 1970) which reported excessive amounts. The data do, however, indicate an increase in the percent rubber for 1974. Not only was the average amount of rubber higher, but that constituent was observed on four of the six filters analyzed at that site for 1974.

Table B-8, which presents the citywide composite summary for the 22 non-NASN filters that were analyzed for 1974, shows a rubber content comparable to that observed at the NASN site for 1974. It is also interesting to note from Table B-4 that the levels of rubber detected at the out of town residential sites (Leeds and Mountain Brook) were much lower than those at the in-town sites. The average percent contribution of rubber in Birmingham is quite typical of the other study cities, however, being seventh out of 14 in that category. It is also typical as far as average mineral content, again ranking seventh out of 14 study cities, and for combustion products, ranking ninth highest.

The individual constituents within the major particulate categories are somewhat unusual in Birmingham, however. The average amount of hematite, the principal ore of iron, was reported as 17 percent, the second highest of the 14 study cities. In addition, iron and/or steel was detected on 17 of the 22 filters and ranged as high as 25 percent of the total mass visible to the microscopist. The average percent iron and steel, although only 2 percent, was the highest observation for that category of the 14 cities. It is also apparent that the analysts had a difficult time determining the precise nature and source of much of the combustion products. In few cities did as much of the combustion-related material get categorized as "miscellaneous soot." It is likely that this confusion was caused by the complex nature of the emissions of the coke ovens and steel furnaces which predominate the industrial activity in the Birmingham area.

Three of the filters from Birmingham were also submitted for determination of particle size as a function of particle type, as shown in Figures B-1 through B-3. Two of these samples were also subjected to chemical analyses. The sample from North Birmingham on October 26, 1974 had 17 $\mu g/m^3$ benzene solubles and nearly 75 $\mu g/m^3$ total carbon with most reported as organic

carbon. The sample from the downtown site on October 14, 1974 had just over 7 $\mu g/m^3$ benzene solubles and nearly 50 $\mu g/m^3$ total carbon, again nearly all reported as organic carbon. This latter sample was also selected for detailed physical analysis, and the results are presented in Table B-9.

Table B-1. METEOROLOGICAL DATA ON SELECTED SAMPLING DAYS (MUNICIPAL AIRPORT, BIRMINGHAM)

Date	Precipitation, in.		Wind speed, mph		Wind direction, deg	
	Day of obs.	Preceding day	Average	Resultant	3-hour observation	Resultant
1/02/70	0	t	1.7	1.5	C, C, C, C 220, 280, C, C	260
3/09/70	0	0	4.6	2.6	60, C, C, 310 260, 280, 210, 50	270
6/23/70	0	0	4.2	4.0	C, C, C, 340 330, 350, 10, C	350
7/04/70	0	0	6.9	5.6	60, C, 270, 20 320, 330, 20, 10	350
12/05/70	t	0	4.5	1.8	C, C, C, 90 210, 270, 320, 10	310
4/11/71	0	0	4.2	0.3	30, C, C, 30 200, 270, 170, 60	260
5/04/71	0	0	4.0	1.1	50, 60, C, C 320, 260, 200, 360	270
5/21/71	0	t	7.6	6.6	C, 130, C, 360 10, 20, 10, 80	20
7/01/71	1.06	0.49	3.0	1.7	C, C, C, 270 280, 160, 160, C	250
1/10/72	2.74	0.71	6.3	4.3	190, 180, 320, C 200, 150, 150, C	190
6/02/72	0	0	1.6	1.4	C, C, C, 30 C, 330, 350, C	350
7/08/72	0	0	3.0	2.6	C, C, C, 160 210, 130, 130, C	160
11/17/72	0	t	7.3	5.8	280, 320, 350, 330 290, 350, 360, 80	330

Table B-1 (continued). METEOROLOGICAL DATA ON SELECTED SAMPLING DAYS (MUNICIPAL AIRPORT, BIRMINGHAM)

Date	Precipitation in.		Wind speed, mph		Wind direction, deg	
	Day of obs.	Preceding day	Average	Resultant	3-hour observation	Resultant
1/04/73	0	0.63	1.9	1.8	C, C, C, C 310, 290, 320, C	310
2/21/73	0	0	5.2	4.9	C, C, C, C 320, 320, 290, 350	320
9/25/73	0	0	9.1	8.5	20, 50, 40, 90 90, 90, 90, 90	80
10/19/73	0	0	3.2	2.3	C, C, C, 150 40, 360, 30, C	30
8/09/74	0	0.26	3.5	1.1	90, 150, C, 170 280, 350, 360, C	320
8/21/74	0	0	5.8	5.2	90, 60, 90, 120 50, 90, 80, 30	80
8/27/74	0.34	0	1.7	0.1	C, C, C, C 150, 360, 240, C	110
10/14/74	0	0	3.9	3.1	C, C, 10, 160 160, 160, 130, 70	150
10/15/74*	0.08	0	4.8		160, 160, 160, 130 70, 150, 200, 160	
10/26/74	0	0	3.2	1.2	40, C, C, 180 340, 280, 90, 50	330
11/01/74	0	0	5.5	2.8	30, 140, 120, 150 210, 180, 40, 30	150

*From 0800 10/14/74 to 0800 10/15/74 (for Leeds sample dated 10/15/74)

Note: C = Calm
t = Trace

Table B-2. ANNUAL AVERAGE CONCENTRATIONS OF SULFATE AND NITRATE IONS AT THE BIRMINGHAM, ALABAMA, NASN SITE NO. 010380003 ($\mu g/m^3$)

Year	Sulfate		Nitrate	
	Arithmetic mean	Geometric mean	Arithmetic mean	Geometric mean
1972	12.19	10.96	2.91	2.65
1973	11.82	11.17	3.68	3.42
1974	16.07	14.16	4.07	3.05

Table B-3a. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN BIRMINGHAM AND VICINITY (DOWNTOWN AUX.)

Date	9 August 1974			21 August 1974			27 August 1974			14 October 1974			26 October 1974			1 November 1974		
TSP ($\mu g/m^3$)	102			82			123			139			214			112		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(7-)	1-30	6	(8+)	<1-65	18	(8+)	1-30	12	(1+)	<1-30	7	(7-)	<1-29	9	(4+)	1-80	7
Quartz	3			1			1			1			3			1		
Calcite	2+			4			3						3			3		
Feldspars																		
Hematite	1			3+			4+											
Mica													1			1-		
Combustion Products	(1)	<1-75	5	(1-)			(1+)	2-96	5	(9-)	1-59	9	(2+)	<1-36	1	(0+)		
Soot:																		
Oil										9-								
Coal																		
Soot				1-			1											
V.F.soot													2+					
Glassy fly ash	1																	
Incinerator fly ash																		
Burned wood																		
Burned paper																		
Magnetite																		
Biological Material	(0+)			(0+)			(0+)			(0+)			(0+)			(1-)	6-75	15
Pollen																		
Spores																		
Paper																		
Starch																		
Misc. plant tissue																1-		
Miscellaneous	(2)	10-90	30	(1)			(1-)			(0+)			(1)	9-60	28	(5)	2-115	50
Iron or steel																		
Rubber	2			1									1			(5)		

Table B-3b. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN BIRMINGHAM AND VICINITY (NO. BIRMINGHAM AUX.)

Date	9 August 1974			21 August 1974			27 August 1974			14 October 1974			26 October 1974			1 November 1974		
TSP ($\mu g/m^3$)	123			198			228			227			351			236		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(8)	1-75	8	(7-)	1-95	15	(5)	<1-65	8	(7-)	<1-60	12	(6+)	<1-45	12	(7+)	1-45	9
Quartz	2+			2-			1-			2			2+			3+		
Calcite	5			2+			2			3			3			3		
Feldspars																		
Hematite				2+			2+			1+			1			1		
Mica																		
Combustion Products	(1+)	<1-30	7	(1-)	1-26	13	(4)	1-75	6	(3+)	<1-70	4	(3)	1-150	12	(2)	<1-65	6
Soot:																		
Oil																		
Coal	1-												3					
Soot				1-			3-			3+						2		
Glassy fly ash	1																	
Incinerator fly ash																		
Burned wood																		
Burned paper																		
Magnetite																		
Biological Material	(0+)			(0+)			(1-)	4-70	30	(<1)			(<1)			(1-)	10-300	18
Pollen																		
Spores																		
Paper																		
Starch																		
Misc. plant tissue							1-									1-		
Miscellaneous	(1-)	8-55	25	(3-)	2-18	10	(1-)			(<1)			(<1)			(<1)		
Iron or steel				2+														
Rubber	1-						1-											

Table B-3c. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN BIRMINGHAM AND VICINITY (WEST END)

Date	9 August 1974			21 August 1974			27 August 1974			14 October 1974			26 October 1974			1 November 1974		
TSP ($\mu g/m^3$)	111			83			103			103			199			71		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(7)	<1-25	9	(7)	<1-45	18	(8+)	1-67	5	(8)	<1-50	7	(6)	<1-80		(8+)	1-97	9
Quartz	3+			4			1			2+			2			3+		
Calcite	1+			1			1			4+			3			4		
Feldspars																		
Hematite	2			2			6+			1			1			1		
Mica																		
Combustion Products	(1)			(2)	3-98	20	(0+)			(1-)	<1-45	11	(1)	<1-26	1-2	(1-)	<1-45	1
Soot:																		
Oil													1					
Coal				1						1-								
Soot																		
Glassy fly ash	1-																	
Incinerator fly ash																		
Burned wood																		
Burned paper																		
Magnetite																		
Fused matter				1+														
Biological Material	(0+)			(1)	3-120	80	(0+)			(0+)			(1-)	9-36	12	(0+)		
Pollen																		
Spores																		
Paper																		
Starch													1-					
Misc. plant tissue				1														
Miscellaneous	(2)	3-100	35	(0+)			(1+)	10-70	33	(1)	8-150	32	(2+)	10-195	35	(1-)	12-80	29
Iron or steel																		
Rubber	2						1			1			2+			1-		

Table B-3d. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN BIRMINGHAM AND VICINITY (MOUNTAIN BROOK AND LEEDS)

Site	Mountain Brook									Leeds		
Date	9 August 1974			14 October 1974			26 October 1974			15 October 1974		
TSP ($\mu g/m^3$)	48			50			78			231		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(3)	1-12	4	(7+)	<1-150		(9)	<1-60	9	(7)		
Quartz	1			5+			7-			3-	<1-50	6
Calcite	1			1-						3	<1-50	6
Feldspars										1-		
Hematite	1			2-			2			1	<1-75	0.5
Mica												
Combustion Products	(7)	<1-5	1	(2)	<1-21	4	(1-)	<1-41	1	(3)		
Soot:												
Oil										1	<1-100	0.5
Coal										1	<1-70	8
Soot	7											
Glassy fly ash				2						1	<1-45	6
Incinerator fly ash												
Burned wood												
Burned paper												
Magnetite												
Biological Material	(0+)			(0+)			(0+)			(<1)		
Pollen												
Spores												
Paper												
Starch												
Misc. plant tissue												
Miscellaneous	(0+)			(1-)			(1-)			(<1)		
Iron or steel												
Rubber				1-			1-					

Table B-4. COMPOSITE SUMMARY OF FILTER ANALYSES FOR SELECTED SITES IN BIRMINGHAM AND VICINITY

Site	Down Town Aux.		West End		No. Birmingham Aux.		Mountain Brook		Leeds
No. of filters	6		6		6		3		1
	Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent
Components	Average	Range	Average	Range	Average	Range	Average	Range	–
Minerals	(60)	14-85	(74)	58-85	(67)	52-80	(64)	28-90	(70)
Quartz	16	8-30	27	10-38	21	7-35	44	10-67	26
Calcite	26	1-40	25	8-45	31	20-52	5	3-8	30
Feldspars									4
Hemtite	18	3-45	22	8-65	14	3-25	15	10-20	10
Mica			<1	0-2	<1				
Other			<1	0-2	1	0-3			
Combustion Products	(24)	2-86	(10)	3-22	(24)	6-38	(32)	3-71	(30)
Soot:									
Oil	14	0-86					<1		10
Coal	<1	0-3	3	0-10	1	0-4	<1		10
Soot	8	0-24	1	0-5	21	0-38	25	0-71	
Glassy fly ash	2	0-9	3	1-6	2	0-9	7	0-20	10
Incinerator fly ash									<1
Burned wood									
Burned paper									<1
Magnetite									
Other			3	0-15					
Biological Material	(1)	0-5	(3)	<1-8	(2)	<1-5	(<1)	0-1	(<1)
Pollen	<1		<1		<1		<1		<1
Spores	<1		<1		<1		<1		<1
Paper	<1		<1		<1		<1		<1
Starch	<1		<1		<1		<1		<1
Misc. plant tissue	1	0-3	3	<1-8	2	<1-5	<1		<1
Miscellaneous	(15)	0-50	(13)	2-23	(7)	<1-27	(3)	1-5	(<1)
Iron or steel	<1		1	0-2	5	<1-23	<1		<1
Rubber	15	0-50	12	0-23	2	0-5	3	1-4	

Table B-5. RESULTS OF REPLICATE ANALYSES OF BIRMINGHAM FILTERS

Site	West End		North Birmingham									Downtown			
Date	14 Oct. 1974		9 Aug. 1974		14 Oct. 1974		26 Oct. 1974		Nov. 1, 1974			27 Aug. 1974		1 Nov. 1974	
TSP ($\mu g/m^3$)	103		123		227		351		236			123		112	
Laboratory	A	A	A	A	A	A	A	B	A	B	B	A	B	A	A
Analysis	1	2	1	2	1	2	1	1	1	:	2	1	1	1	2
Components															
Minerals	(82)	(86)	(80)	(86)	(66)	(60)	(65)	(5)	(75)	(30)	(26)	(83)	(6)	(43)	(69)
Quartz	25	12	25	30	20	25	25		35			8		8	30
Calcite	45	40	52	21	31	23	29		30			30		30	32
Feldspars		4													
Hematite	10	30	3	35	15	12	8		10			45		5	7
Mica	2	<1													
Other							3								
Combustion Products	(6)	(14)	(15)	(13)	(34)	(35)	(32)	(95)	(19)	(70)	(74)	(13)	(94)	(2)	(26)
Soot:															
Oil		5				8									
Coal		4	4	4		16	32	5		5	28				
Soot	5				33				19			11		2	26
Glassy	1	5	9	9	1	11			tr			2			
fly ash								90		65	46				
Incinerator fly ash		<1													
Burned wood															
Burned paper		<1													
Magnetite															
Biological Material	(2)	(<1)	(<1)	(<1)	(<1)	(2)	(<1)	(<1)	(5)	(<1)	(<1)	(<1)	(<1)	(5)	(<1)
Pollen	<1	<1			<1							tr		tr	
Spores	<1	<1			<1				tr					tr	tr
Paper	<1	<1		<1	<1									tr	<1
Starch	tr		tr	<1	<1	tr	<1					tr		<1	
Misc. plant tissue	2	<1			<1	2	<1		5					5	<1
Miscellaneous	(10)	(<1)	(5)	(1)	(<1)	(3)	(3)	(<1)	(1)	(<1)	(<1)	(4)	(<1)	(50)	(5)
Iron or steel	<1	<1	<1	<1	<1	1	3		1			3			<1
Rubber	9		5	1								1		50	5

Table B-6a. RESULTS OF FILTER ANALYSES FOR TRENDS AT NASN SITE NO. 010380003 IN BIRMINGHAM (1970)

Date	2 January 1970			9 March 1970			23 June 1970			4 July 1970			5 December 1970		
TSP ($\mu g/m^3$)	142			156			184			629			216		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(2)			(9)	1-60	8	(8)	1-60	6	(9-)	1-60	7	(1)	2-24	5
Quartz	1	2-60	20	3			2+			3-			1-		
Calcite	1	1-50	15	3			4			2					
Feldspars															
Hematite	1-	1-30	5	3			1			4					
Mica															
Combustion Products	(1+)			(1)	<1-20	1	(2)	<1-30	8	(1)	<1-65	2	(9)	<1-48	<1
Soot:															
Oil				1						} 1					
Coal															
V.fine soot							1						9		
Glassy fly ash															
Incinerator fly ash	1	1-75	25												
Burned wood															
Burned paper															
Magnetite															
Other							1								
Biological Material	(0+)			(0+)			(0+)			(0+)			(0+)		
Pollen															
Spores															
Paper															
Starch															
Misc. plant tissue															
Miscellaneous	(7-)			(0+)			(0+)			(0+)			(0+)		
Iron or steel															
Rubber	7-	10-150	50												

Table B-6b. RESULTS OF FILTER ANALYSES FOR TRENDS AT NASN SITE NO. 010380003 IN BIRMINGHAM (1971)

Date	11 April 1971			4 May 1971			21 May 1971			1 July 1971		
TSP ($\mu g/m^3$)	100			165			255			105		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size μm	Quantity, tenths	Size range, μm	Avg. size μm
Minerals	(4+)	<1-40	2	(7+)	<1-45	9	(8)	<1-60	5	(6)		
Quartz	1			2			3			1+	5-65	30
Calcite	1			4+			2			2+	2-75	15
Feldspars										1	2-60	20
Hematite	2+			1			1-			1	1-50	10
Mica												
Other							2+					
Combustion Products	(0+)			(2+)	<1-66	<1	(1)	2-52	6	(4-)		
Soot:												
Oil										1	5-50	20
Coal										1	1-80	25
Soot				2+			1			1	5-25	15
Glassy fly ash												
Incinerator fly ash												
Burned wood												
Burned paper												
Magnetite										1-	10-40	20
Biological Material	(5+)	20-50	38	(0+)			(0+)			(0+)		
Pollen												
Spores	5+											
Paper												
Starch												
Misc. plant tissue												
Miscellaneous	(0+)			(0+)			(1)	6-50	9	(1-)		
Iron or steel							1-			1-		
Rubber												

Table B-6c. RESULTS OF FILTER ANALYSES FOR TRENDS AT NASN SITE NO. 010380003 IN BIRMINGHAM (1972)

Date	10 January 1972			2 June 1972			8 July 1972			17 November 1972		
TSP ($\mu g/m^3$)	35			297			80			164		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(7)			(8)	<1-12	2	(7)	<1-18	2	(7-)	1-45	7
Quartz	2	10-60	15	3			4			2		
Calcite	2	2-50	20	4+			2			3+		
Feldspars										1-		
Hematite	3	1-70	15				1					
Mica												
Clay												
Combustion Products	(2)			(2)	<1-4	1	(3-)			(2+)	<1-75	2
Soot:												
Oil	1	5-50	25									
Coal	1-	5-60	20	2			1-					
Soot										2+		
Glassy fly ash	1-	5-25	10				2					
Incinerator fly ash												
Burned wood												
Burned paper												
Magnetite												
Biological Material	(0+)			(0+)			(0+)			(0+)		
Pollen												
Spores												
Paper												
Starch												
Misc. plant tissue												
Miscellaneous	(1)			(0+)			(0+)			(1)	8-90	25
Iron or steel												
Rubber	1	10-80	30							1		

Table B-6d. RESULTS OF FILTER ANALYSES FOR TRENDS AT NASN SITE NO. 010380003 IN BIRMINGHAM (1973)

Date	4 January 1973			21 February 1973			25 September 1973			19 October 1973		
TSP ($\mu g/m^3$)	143			172			116			225		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(5)			(8+)			(7+)	<1-45	5	(3+)	1-39	5
Quartz	2	10-70	30	4			3+			1		
Calcite	2	5-30	25	4			3			2		
Feldspars	1	2-60	20	1-								
Hematite							1-			1	1-16	
Mica												
Clay							1-					
Combustion Products	(4-)			(1+)	<1-10	1	(2)	<1-65	20	(6+)	<1-25	5
Soot:												
Oil	1+											
Coal				1+								
Soot	1-	<1-2	1							5		
Glassy fly ash	1-	5-25	15				1-					
Incinerator fly ash	1											
Burned wood										} 1		
Burned paper												
Magnetite												
Other							1					
Biological Material	(0+)			(0+)			(0+)			(0+)		
Pollen												
Spores												
Paper												
Starch												
Misc. plant tissue												
Miscellaneous	(1+)			(0+)			(1-)	<1-165	30	(0+)		
Iron or steel												
Rubber	1+						1-					

Table B-6e. RESULTS OF FILTER ANALYSES FOR TRENDS AT NASN SITE NO. 010380003 IN BIRMINGHAM (1974)

Date	9 August 1974			21 August 1974			27 August 1974			14 October 1974			26 October 1974			1 November 1974		
TSP ($\mu g/m^3$)	93			65			98			184			190			92		
Components	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm	Quantity, tenths	Size range, μm	Avg. size, μm
Minerals	(4)	1-34	6	(9+)	<1-36		(9+)	<1-20	5	(5)	1-40	15	(1+)	<1-15	1	(9)		
Quartz	2			8			1-			2-			1-			1		
Calcite	1-			1			2+			2			1-			7+		
Feldspars																		
Hematite	1+						7			1			1-					
Mica																		
Combustion Products	(3)	<1-60	6	(0+)			(1-)			(3+)			(9-)			(0+)		
Soot:																		
Oil																		
Coal	1																	
Soot																		
Glassy fly ash	2						1-			2	<1-40	3	9-					
Incinerator fly ash																		
Burned wood																		
Burned paper																		
Magnetite																		
Other										1+	1-30	4						
Biological Material	(0+)			(0+)			(0+)			(0+)			(0+)			(0+)		
Pollen																		
Spores																		
Paper																		
Starch																		
Misc. plant tissue																		
Miscellaneous	(3)	7-60	35	(1-)			(0+)			(2-)			(0+)			(1-)	15-100	45
Iron or steel										(1+)	20-150	35						
Rubber	3			1-												1-		

Table B-7. COMPOSITE SUMMARY OF FILTER ANALYSES FOR NASN SITES IN BIRMINGHAM AND VICINITY (BY YEAR)

Year	1970		1971		1972		1973		1974	
No. of filters	5		4		4		4		6	
	Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent		Quantity, percent	
Components	Average	Range	Average	Range	Average	Range	Average	Range	Average	Range
Minerals	(57)	10-90	(64)	43-80	(73)	66-80	(61)	35-86	(63)	13-95
Quartz	19	5-30	19	8-30	30	22-38	26	8-40	23	4-79
Calcite	20	3-40	24	10-45	30	20-45	27	18-40	23	4-75
Feldspars			3	0-10	2	0-5	3	0-10		
Hematite	18	2-40	12	7-25	11	1-30	4	1-9	17	2-68
Mica										
Other	<1	0-1	6	0-25			1	0-5		
Combustion Products	(29)	10-89	(18)	2-36	(22)	18-26	(33)	15-63	(27)	3-87
Soot:										
Oil	1	0-5	3	0-12	2	0-8	4	0-15		
Coal	1	0-5	3	0-12	2	0-5			2	0-10
Soot	22	0-89	8	0-23	10	0-20	18	1-52	15	0-86
Glassy fly ash	1	0-2	3	<1-8	8	0-22	4	1-5	8	1-20
Incinerator fly ash	2	0-8					2	0-10		
Burned wood							} 2	0-10		
Burned paper									2	0-15
Magnetite										
Other	2	0-10	1	0-4			3	0-12		
Biological Material	(1)	<1-2	(14)	<1-53	(<1)	(0-1)	(1)	<1-2	(1)	0-3
Pollen	<1		13	0-53	<1		<1		<1	
Spores			<1				<1		<1	
Paper	<1		<1		<1		<1	0-2		
Starch	<1		<1		<1		<1		<1	
Misc. plant tissue	1	0-2	1	0-1	<1		1	0-2	1	0-3
Miscellaneous	(13)	0-66	(4)	0-9	(5)	0-10	(5)	0-15	(9)	0-30
Iron or steel	<1	0-1	<1		<1		<1		<1	
Rubber	13	0-66	4	0-9	5	0-10	5	0-15	9	0-30

Table B-8. CITYWIDE COMPOSITE SUMMARY OF FILTER ANALYSES IN BIRMINGHAM

No. of filters	22[a]	
	Quantity, percent	
Components	Average	Range
Minerals	(66)	14-90
Quartz	25	8-67
Calcite	24	3-52
Feldspars	<1	0-4
Hematite	17	3-65
Mica	<1	0-2
Other	<1	0-3
Combustion Products	(22)	2-86
Soot:		
Oil	4	0-86
Coal	2	0-10
Misc. soot	12	0-71
Glassy fly ash	3	0-20
Incinerator fly ash	<1	
Burned wood		
Burned paper	<1	
Magnetite		
Carbon black		
Other	1	0-15
Biological Material	(2)	0-8
Pollen	<1	
Spores	<1	
Paper	<1	
Starch	<1	
Misc. plant tissue	2	0-8
Leaf trichomes		
Miscellaneous	(10)	0-50
Iron or steel	2	0-25
Rubber	8	0-50
Other		

[a]Excludes filter analyses of NASN site samples.

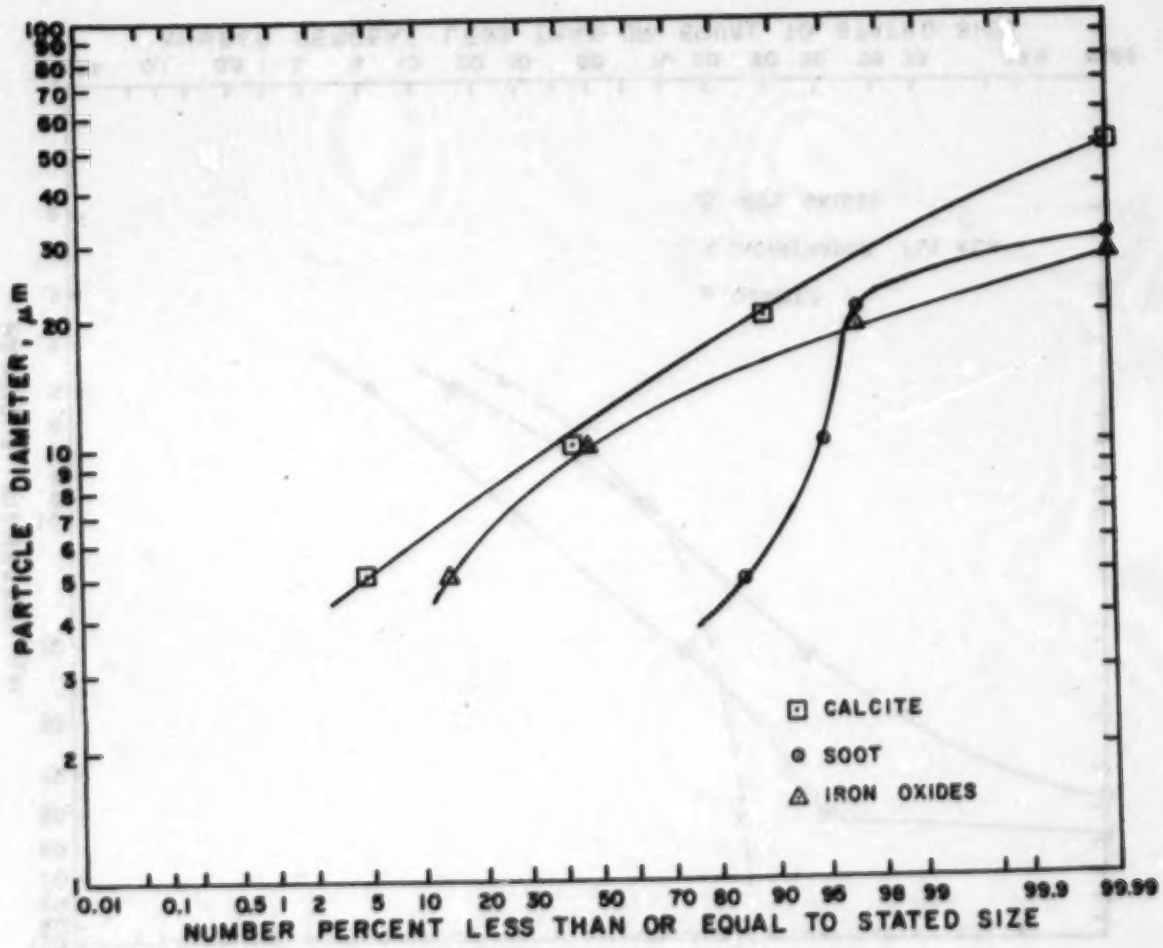

Figure 6. Cumulative size distributions for three particle types, Downtown site, Birmingham October 14, 1974

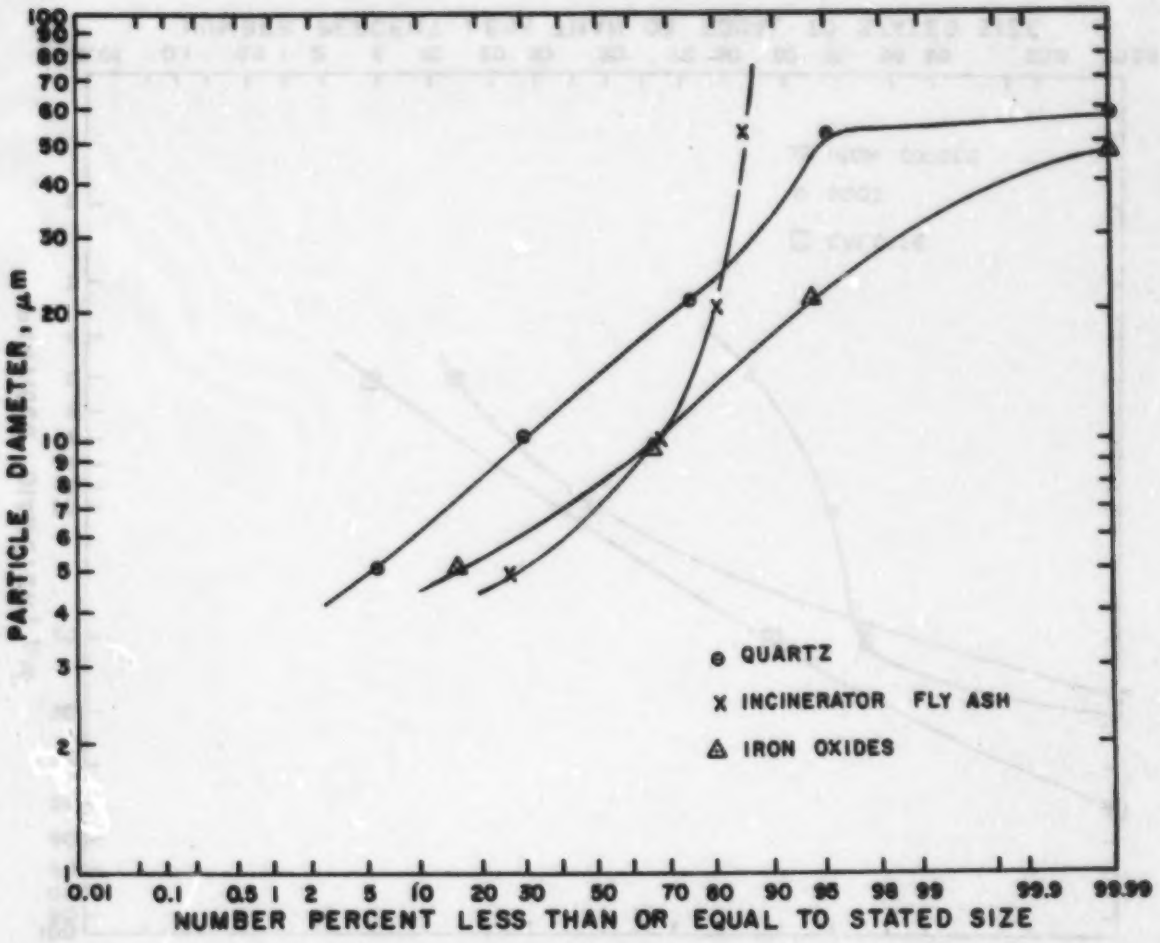

Figure 7. Cumulative size distributions for three particle types, North Birmingham site, Birmingham, October 26, 1974

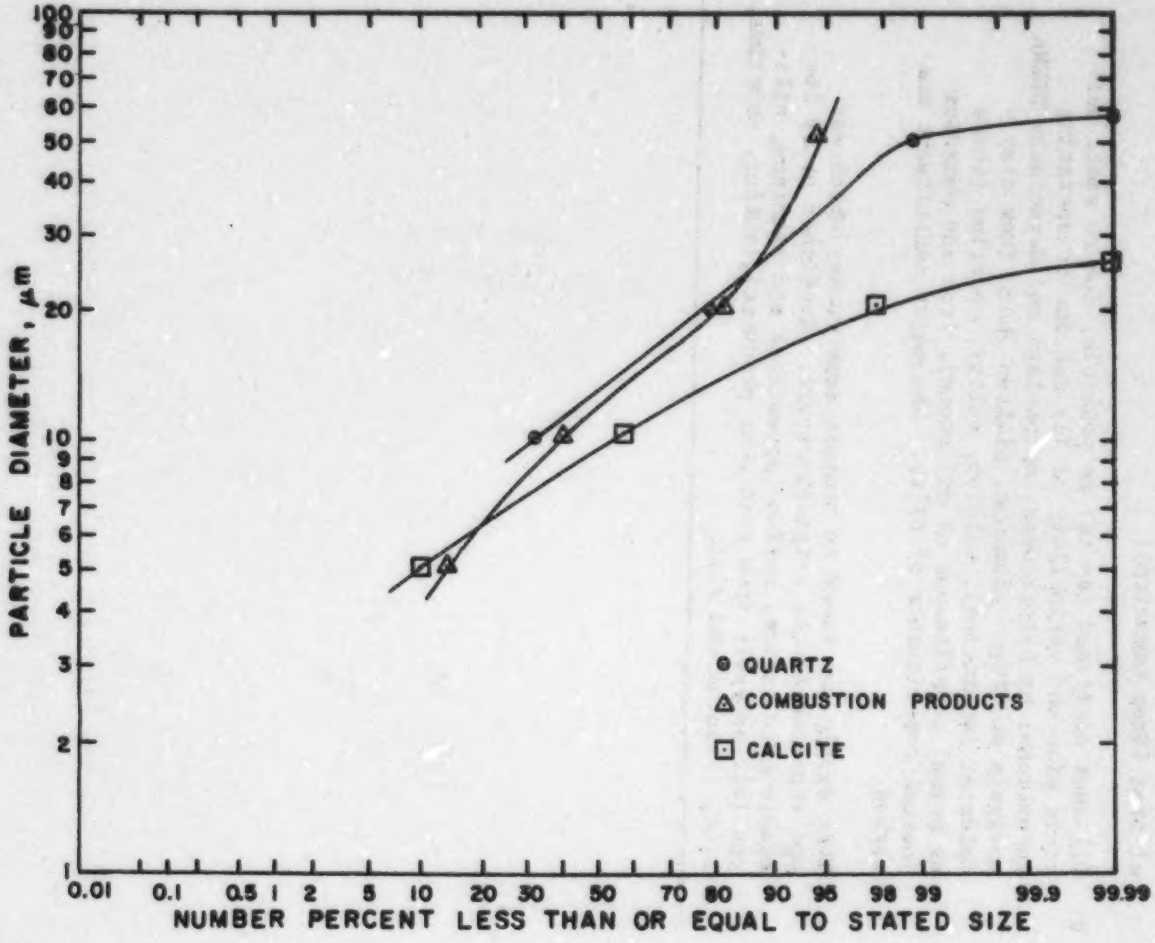

Figure 8. Cumulative size distributions for three particle types, North Birmingham site, Birmingham, November 1, 1974

Table B-9. DETAILED PHYSICAL EXAMINATION: DOWNTOWN, BIRMINGHAM, OCTOBER 14, 1974

a. Quartz confirmed by dispersion handling and (-) uniaxial interference figure. EDXRA shows only silicon and trace of iron (from hematite).

b. Oil soot confirmed (as far as possible, due to small particle size and variability of fly ash due to operating conditions) by brittleness, morphology and especially EDXRA analysis showing: aluminum, silicon (both from clay - feldspar impurities), calcium, sulfur, chlorine (these as normal constituents of oil soots), iron and vanadium (normal constituents of oils). The major constituent was carbon.

c. This sample was found to contain some rubber which was not reported in the original report. Confirmed as by its elastomeric nature, surface appearance and aluminum, silicon (all probably from road wear products), sulfur, chlorine, iron, titanium and zinc.